OPTIMIZATION EVALUATION

PALERMO WELLFIELD SUPERFUND SITE
CITY OF TUMWATER, THURSTON COUNTY, WASHINGTON

Report of the Optimization Evaluation
Site Visit Conducted at the Palermo Wellfield Superfund Site
August 25, 2011

November 30, 2011

EXECUTIVE SUMMARY

Optimization Background

USEPA's working definition of optimization as of June 2011 is as follows:

"A systematic site review by a team of independent technical experts, at any phase of a cleanup process, to identify opportunities to improve remedy protectiveness, effectiveness, and cost efficiency, and to facilitate progress toward site completion."

An optimization evaluation considers the goals of the remedy, available site data, conceptual site model (CSM), remedy performance, protectiveness, cost-effectiveness, and closure strategy. A strong interest in sustainability has also developed in the private sector and within Federal, State, and Municipal governments. Consistent with this interest, optimization now routinely considers green remediation and environmental footprint reduction during optimization evaluations. An optimization evaluation includes reviewing site documents, interviewing site stakeholders, potentially visiting the site for one day, and compiling a report that includes recommendations in the following categories:

- Protectiveness
- Cost-effectiveness
- Technical improvement
- Site closure
- Environmental Footprint Reduction

The recommendations are intended to help the site team identify opportunities for improvements in these areas. In many cases, further analysis of a recommendation, beyond that provided in this report, may be needed prior to implementation of the recommendation. Note that the recommendations are based on an independent evaluation, and represent the opinions of the evaluation team. These recommendations do not constitute requirements for future action, but rather are provided for consideration by the Region and other site stakeholders. Also note that while the recommendations may provide some details to consider during implementation, the recommendations are not meant to replace other, more comprehensive, planning documents such as work plans, sampling plans, and quality assurance plans.

Site-Specific Background

The Palermo Wellfield Superfund Site (the Site) is located near Interstate Highway 5 and Trosper Road in Tumwater, Washington. The Site includes a City-operated water-supply wellfield and an adjacent residential neighborhood in the Deschutes River Valley (sometimes referred to as the Palermo Valley in site documents), as well as upland source areas including the (current) Washington Department of Transportation (WSDOT) Materials Testing Laboratory (MTL), a former WSDOT MTL, and the Southgate Dry Cleaners business. Trichloroethene (TCE) was detected at the wellfield in 1993. Subsequent investigations identified a TCE groundwater plume over 3,000 ft long and 600 ft wide, and a smaller tetrachloroethene (PCE) plume near the Southgate Dry Cleaners site.

The Site remedy for groundwater includes capture of contaminated groundwater at the Palermo Wellfield with air-stripping to reduce the levels of TCE and PCE below maximum contaminant levels (MCLs). The air strippers have been in operation since 1999.

Additionally, a soil vapor extraction system (SVE) was operated from 1998 to 2000 at the Southgate Dry Cleaners site to reduce the levels of PCE near this source area.

Finally, a French drain system has been installed at the western edge of the Palermo neighborhood to prevent surface discharge of contaminated groundwater to home crawlspaces and to mitigate the potential for indoor-air exposure risks at the homes in the neighborhood. Groundwater collected in the French drain system is treated through aeration in a small lagoon and discharged to a ditch that flows to the Deschutes River.

Summary of Conceptual Site Model (CSM)

Figure 1 is a cross-section illustration that summarizes the CSM. Volatile-organic-compound (VOC) contamination released at the surface and/or in the shallow subsurface from the Southgate Dry Cleaners and both the current and former WSDOT MTL facilities has impacted groundwater at the site. The soils are relatively permeable (described as sands) and low in organic carbon. In addition, the releases in some cases may have occurred approximately 25 years before remedial-investigation (RI) sampling occurred. These factors contributed to relatively low soil concentrations observed during the RI and may have resulted in relatively weak continuing sources of dissolved groundwater contamination in 2010 at these previously identified sources. The relatively high groundwater flow rates and low organic carbon have contributed to contaminant flushing over the period of three to four decades from the time of the original releases until present. As a result, the majority of contamination associated with the original releases appears to have migrated away from the source areas and is now present in the vicinity of the Palermo neighborhood. However, one or more of the historic source areas may be continuing to impact groundwater.

The known extent of VOC groundwater plume is approximately 3,000 feet long and includes the Palermo Wellfield. The fate of contaminated groundwater includes surface expression as seeps in the vicinity of the Palermo neighborhood, capture by the subdrain system, extraction by the Palermo Wellfield, or potentially migration beyond the Palermo neighborhood and Palermo Wellfield. Contaminant migration pathways begin at the water table near the source areas and gradually migrate deeper as a result of regional pumping and recharge. Due the relatively eastern location of the main PCE source area (Southgate Dry Cleaners), it is likely that the PCE has remained sufficiently shallow to be captured by the subdrain system as reflected by the PCE concentrations in the subdrain and the absence of PCE detections in groundwater downgradient of the subdrain. PCE concentrations have been decreasing in the subdrain because the PCE source was mostly removed and the PCE is being flushed from the aquifer. TCE contamination, which started migrating from sources further west, has had the opportunity to migrate slightly deeper and is more dispersed. The TCE plume core likely migrates under the subdrain. The removal of water from the subdrain and the surface expression of seeps due to the abrupt change in regional topography result in an upward gradient in the valley such that some of the deeper TCE migrates closer to the surface in the Palermo neighborhood and some is extracted by the Palermo Wellfield. Shallow groundwater contaminated with TCE and PCE and/or shallow groundwater discharging to the surface represent potential vapor intrusion (VI) exposures for residents in the Palermo neighborhood north of the Palermo Wellfield.

Summary of Findings

Based on a review of the information provided to the optimization team, the Site visit conducted on August 25, 2011, and interviews with persons knowledgeable about the Site, the following main findings have been identified:

- The definition of the groundwater plume is incomplete.
- Plume capture by the subdrain and wellfield is likely not complete.
- VI remains a concern and additional information is needed.
- There is insufficient information to determine if historic sources continue to be ongoing sources of contamination.

Summary of Recommendations

Recommendations are provided to improve remedy effectiveness, reduce cost, provide technical improvement, and assist with accelerating site closure. The recommendations in these areas are as follows:

Improving effectiveness – sample additional existing and new wells to improve plume delineation and the CSM, update the capture zone evaluation based on the new information, update and improve the indoor air sampling in the Palermo neighborhood, install vapor mitigation systems as appropriate, evaluate the feasibility and costs of improving the subdrain extraction rate and influence, evaluate the effectiveness of the historic SVE system at remediating soils, and formalize an agreement with City of Tumwater for wellfield operation.

Reducing cost – refine the long-term monitoring (LTM) program after completion of additional investigation work. Cost reductions will not occur in the immediate future but rather after full delineation is attained and concentration trends are established.

Technical improvement – improve the presentation of data in reports and manage data electronically.

Site closure **–** Update the official site remedy description after completion of the other recommendations.

No opportunities were identified for meaningful reduction of the remedy environmental footprint.

NOTICE

Work described herein was performed by Tetra Tech GEO for the U.S. Environmental Protection Agency (USEPA). Work conducted by Tetra Tech GEO, including preparation of this report, was performed under Work Assignment #58 of USEPA contract EP-W-07-078 with Tetra Tech EM, Inc., Chicago, Illinois. Mention of trade names or commercial products does not constitute endorsement or recommendation for use.

PREFACE

This report was prepared as part of a national strategy to expand Superfund optimization from remedial investigation to site completion implemented by the United States Environmental Protection Agency Office of Superfund Remediation and Technology Innovation (USEPA OSRTI). The project contacts are as follows:

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LIST OF ACRONYMS

amsl	above mean sea level
bgs	below ground surface
COC	chemical of concern
CSIA	compound specific isotope analysis
CSM	conceptual site model
ESD	explanation of significnat difference
FS	feasibility study
FYR	Five Year Review
LTM	long term monitoring
MCL	maximum contaminant limit
MTCA	Model Toxics Control Act
MTL	materials testing laboratory
OSRTI	Office of Superfund Remediation and Technology Innovation
P&T	pump and treat
PCE	tetrachloroethylene (perchloroethylene)
PVC	polyvinyl chloride
RAO	remedial action objective
RG	remediation goal
RI	remedial investigation
ROD	Record of Decision
RSE	remedial system evaluation
SVE	soil vapor extraction
TCE	trichloroethylene
TtGEO	Tetra Tech GEO
USEPA	United States Environmental Protection Agency
UST	underground storage tank
VI	vapor intrusion
VOC	volatile organic compound
WSDOE	Washington State Department of Ecology
WSDOT	Washington State Department of Transportation

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1.0 INTRODUCTION

1.1 PURPOSE

During fiscal years 2000 and 2001 independent reviews called Remediation System Evaluations (RSEs) were conducted at 20 operating Fund-lead pump and treat (P&T) sites (i.e., those sites with P&T systems funded and managed by Superfund and the States). Due to the opportunities for system optimization that arose from those RSEs, USEPA OSRTI has incorporated RSEs into a larger post-construction complete strategy for Fund-lead remedies as documented in *OSWER Directive No. 9283.1-25, Action Plan for Ground Water Remedy Optimization*. Concurrently, USEPA developed and applied the Triad approach to optimize site characterization and development of a conceptual site model (CSM). USEPA has since expanded the definition of optimization to encompass investigation stage optimization using the Triad approach, optimization during design, and RSEs. USEPA's working definition of optimization as of June 2011 is as follows:

> *"A systematic site review by a team of independent technical experts, at any phase of a cleanup process, to identify opportunities to improve remedy protectiveness, effectiveness, and cost efficiency, and to facilitate progress toward site completion."*

As stated in the definition, optimization refers to a "systematic site review", indicating that the site as a whole is often considered in the review. Optimization can be applied to a specific aspect of the remedy (e.g., focus on long-term monitoring [LTM] optimization or focus on one particular operable unit), but other site or remedy components are still considered to the degree that they affect the focus of the optimization. An optimization evaluation considers the goals of the remedy, available site data, CSM, remedy performance, protectiveness, cost-effectiveness, and closure strategy. A strong interest in sustainability has also developed in the private sector and within Federal, State, and Municipal governments. Consistent with this interest, OSRTI has developed a Green Remediation Primer (http://cluin.org/greenremediation/), and now routinely considers green remediation and environmental footprint reduction during optimization evaluations. The evaluation includes reviewing site documents, potentially visiting the site for one day, and compiling a report that includes recommendations in the following categories:

- Protectiveness
- Cost-effectiveness
- Technical improvement
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The recommendations are intended to help the site team identify opportunities for improvements in these areas. In many cases, further analysis of a recommendation, beyond that provided in this report, may be needed prior to implementation of the recommendation. Note that the recommendations are based on an independent evaluation, and represent the opinions of the evaluation team. These recommendations do not constitute requirements for future action, but rather are provided for consideration by the Region and other site stakeholders. Also note that while the recommendations may provide some details to consider during implementation, the recommendations are not meant to replace other, more comprehensive, planning documents such as work plans, sampling plans, and quality assurance plans.

The national optimization strategy includes a system for tracking consideration and implementation of the optimization recommendations and includes a provision for follow-up technical assistance from the optimization team as mutually agreed upon by the site management and USEPA OSRTI.

The Palermo Wellfield Superfund Site (the Site) is located near Interstate Highway 5 and Trosper Road in Tumwater, Washington. The Site includes a City-operated water-supply wellfield and an adjacent residential neighborhood in the Deschutes River Valley Valley (sometimes referred to as the Palermo Valley in site documents), as well as upland source areas including the (current) Washington Department of Transportation (WSDOT) Materials Testing Laboratory (MTL), a former WSDOT MTL, and the Southgate Dry Cleaners business. Trichloroethene (TCE) was detected at the wellfield in 1993. Subsequent investigations identified a TCE groundwater plume over 3,000 ft long and 600 ft wide, and a smaller tetrachloroethene (PCE) plume near the Southgate Dry Cleaners site. USEPA Region 10 nominated the site for an optimization review due an interest in updating the CSM and concerns regarding plume migration control and the potential for vapor intrusion (VI).

1.2 TEAM COMPOSITION

The optimization team consists of the following individuals:

Name	Affiliation	Phone	Email
Steve Dyment	USEPA HQ/OSRTI	703-603-9903	dyment.stephen@epa.gov
Greg Council	Tetra Tech GEO	770-619-9950	greg.council@tetratech.com
Tim Costello	Tetra Tech GEO	916-853-4584	tim.costello@tetratech.com

In addition, Doug Sutton from Tetra Tech GEO assisted with project direction, report preparation/review, and evaluation of the environmental footprint of remedial components.

1.3 DOCUMENTS REVIEWED

The following documents were reviewed. The reader is directed to these documents for additional site information that is not provided in this report.

- *Remedial Action Construction Documentation Subdrain System and Treatment Lagoon* (URS Greiner, Inc. – March 6, 2011)
- *Action Memorandum for a Removal Action* (USEPA – June 27, 1997)
- *Soil Vapor Extraction System Operation, Decommissioning, and Confirmation Sampling* (URS Corporation – August 11, 2000)
- *Final Trip Report* (URS Greiner, Inc. – October 2001)
- *Final 2010 Annual Groundwater Long-Term Monitoring Report* (Parametrix – April 2011)
- *Final Feasibility Study* (URS Greiner, Inc. – May 1999)
- *Final Remedial Investigation* (URS Greiner, Inc. – June 1999)
- *Technical Memorandum Modeling of Site Characteristics* (URS Greiner, Inc. – June 1999)
- *First Five Year Review Report* (URS Greiner, Inc. – September 2003)
- *Final Second Five Year Review Report* (Parametrix – September 2008)

- *Final Record of Decision* (USEPA – October 1999)
- *Expert Report of Dimitri Vlassopoulos, Ph.D* (Dimitri Vlassopoulos – May 2006)
- *Brewery City Pizza Removal Assessment* (Ecology & Environment, Inc. – August 30, 1997)
- *Liability Status of Chevron at the Palermo Superfund Site* (USEPA – October 11, 2002)
- *City of Tumwater 2010 Water System Plan* (HDR – April 2011)
- *Underground Storage Tank Closure and Independent Remedial Action Report* (July 1, 1996)

Also, historical aerial photographs and topographic maps were obtained and reviewed during this evaluation. Those materials, which were obtained from Environmental Data Resources, are provided in Attachment G.

1.4 QUALITY ASSURANCE

This optimization evaluation utilizes existing environmental data to interpret the CSM, evaluate remedy performance, and make recommendations to improve the remedy. The quality of the existing data is evaluated by the optimization team prior to using the data for these purposes. The evaluation for data quality includes a brief review of how the data were collected and managed (where practical, the site Quality Assurance Project Plan is considered), the consistency of the data with other site data, and the use of the data in the optimization evaluation. Data that are of suspect quality are either not used as part of the optimization evaluation or are used with the quality concerns noted. Where appropriate, this report provides recommendations made to improve data quality.

1.5 PERSONS CONTACTED

A stakeholders meeting was held on August 25, 2011, at the offices of Washington State Department of Ecology (WSDOE) in Lacey, Washington. In addition to the optimization team, the following persons were present for the stakeholders meeting:

Name	Affiliation	Email Address
Claire Hong	USEPA Region 10 (RSE)	hong.claire@epa.gov
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Guy Barrett	WSDOE	gbar461@ecy.wa.gov
Barbara Trejo	Washington State Department of Health	barbara.trejo@doh.wa.gov

After the stakeholders meeting, the entire group toured the site. A portion of the Site tour was conducted at the Palermo Wellfield property. For that portion of the tour, three City of Tumwater employees participated: Dan Smith (Water Resources Program Manager; desmith@ci.tumwater.wa.us), Dennis Ash, and Steve Craig.

2.0 SITE BACKGROUND

2.1 LOCATION

The Palermo Wellfield Superfund Site (the Site) is located near Interstate Highway 5 and Trosper Road in Tumwater, Thurston County, Washington. Tumwater is located about 60 miles south of Seattle in the Puget Sound Basin of western Washington. The Site includes a City-operated water-supply wellfield and an adjacent residential neighborhood in the Deschutes River Valley, as well as upland source areas including the (current) WSDOT MTL, a former WSDOT MTL, and the Southgate Dry Cleaners business. TCE was detected in the City water supply in 1993 at a level exceeding the maximum contaminant level (MCL). Subsequent investigations identified a TCE groundwater plume over 3,000 ft long and 600 ft wide, and a smaller PCE plume near the Southgate Dry Cleaners site. The western (upgradient) end of the TCE plume is near the intersection of Trosper Road and Littlerock Road, about 800 ft south of Barnes Lake. The TCE plume extends to the east northeast, across the Palermo Bluff (i.e. the steep topographic drop into the Deschutes River Valley), and underneath the Palermo neighborhood just west of the Tumwater Valley Golf Course. The City's Palermo Wellfield is located south of and adjacent to the Palermo neighborhood (Attachment A: Exhibit A-1).

2.2 SITE HISTORY

2.2.1 HISTORIC LAND USE AND OPERATIONS

The City of Tumwater, originally called New Market, was the first American settlement on the Puget Sound, dating to 1845. The City is well known for a brewery that was established in 1896 and used groundwater for production. The brewery is no longer in operation. The Palermo Wellfield and Palermo neighborhood in the Deschutes River Valley were part of a strawberry farm once owned by the Palermo family. The City began groundwater extraction at the present wellfield in the 1930s and the neighborhood was developed in the 1950s.

West of the valley is a steep bluff and upland area. This area started to become urbanized in the 1950s once Interstate 5 was constructed in the area. The Southgate Shopping Center (also referred to as the Southgate Mall in site documents) and other developments along Trosper Road were developed in the 1970s.

2.2.2 CHRONOLOGY OF ENFORCEMENT AND REMEDIAL ACTIVITIES

Discovery of TCE in the water supply at the Palermo Wellfield in 1993 resulted in a series of investigations and remedial actions. Multiple potential sources of TCE and PCE were identified in the upland areas, including the Southgate Dry Cleaners (PCE) the (current) WSDOT MTL north of Trosper Road (TCE), and a former WSDOT MTL south of Trosper Road. The Site was placed on the National Priorities List (NPL) in 1997.

In 1998 a soil-vapor extraction (SVE) system was installed near the Southgate Dry Cleaners PCE source. This SVE system was operated from March 1998 until June 2000.

A wellhead air-stripper treatment system was installed for the Palermo Wellfield. This system was put into operation in 1999 and operation has continued to present. This treatment system is operated by the City of Tumwater as part of the City's water supply system.

Remedial Investigation (RI) and Feasibility Study (FS) reports were finalized in 1999, and a Record of Decision (ROD) was finalized in October of that year. Among other items, the ROD included the following remedy components:

- The wellhead air-stripper treatment system for the Palermo Wellfield that was already in use at the time of the ROD;
- The SVE system at Southgate Dry Cleaners that had already begun operation at the time of the ROD; and
- Construction of a subdrain system at the base of the valley bluff just west of the Palermo neighborhood to lower the water table in the neighborhood.

Semiannual monitoring of groundwater and remedy performance monitoring has occurred since 2001.

The subsurface shallow-groundwater drainage system was constructed along the western edge of the Palermo neighborhood in 2000-2001. Operation of the system began in 2002.

Two five-year-review (FYR) reports have been completed for USEPA: the first in 2003 and the second in 2008. The Second FYR listed several recommendations and follow-up actions. Among the recommendations and follow-up actions that are relevant to this optimization evaluation are the following:

- Prepare and record a deed restriction at Southgate Dry Cleaners or sample SVE treated soil to determine whether actual soil concentrations require an Institutional Control.
- Conduct a capture zone analysis to assess whether or not the TCE plume is being fully captured by the operation of the Palermo Wellfield. Analysis shall assess the vertical distribution of contaminants within the aquifer.
- Evaluate the groundwater monitoring system to assess if existing wells are adequate for monitoring plume migration and remediation and to determine if additional monitoring points are required in the downgradient portion of the Site.
- Re-evaluate the CSM and Remedial Action Objectives (RAOs) since natural attenuation is not a significant process for reducing TCE and PCE concentrations in groundwater.
- Continue indoor air monitoring to ensure concentrations of TCE and PCE remain below 1.46 $\mu g/m^3$ and 4.38 $\mu g/m^3$, respectively.
- Re-evaluate the remediation goal (RG) for the groundwater-to-indoor air pathway.

In 2005, the U.S. government initiated a cost-recovery case against two potentially responsible parties: WSDOT and Southgate Development Corp. In 2007, a settlement was finalized with Southgate and the court issued a judgment identifying WSDOT as liable for past and future response actions related to TCE contamination at this Site.

2.3 Potential Human and Ecological Receptors

The primary receptors of potential concern are:

- Users of City water; and
- Occupants of buildings that lie within the aerial footprint of the TCE and PCE plume, especially residents of the Palermo neighborhood.

The air-stripper treatment of Palermo Wellfield water has been effective in eliminating potential risks to City water users from TCE or PCE contamination because, based on periodic test data, treated water concentrations are less than MCLs.

Elimination of potential risk to building occupants is less definitive due to data sparseness, but all indoor air data collected between 2004 and 2008 in the Palermo neighborhood indicated that concentrations in air met the indoor-air RGs established in the 1999 ROD. No indoor-air data have been collected since 2008, and there has been no evaluation of VI in the upland areas.

Other potential receptors may include:

- Private well users within the plume; and
- Humans and ecological receptors that come into contact with contaminated surface water either at the base of the Palermo Bluff in seeps within the valley, or in drainage ditches.

Presently, there are no known or suspected private-well users in the plume area. City water service is available throughout the area.

Human exposure to seep water was evaluated quantitatively in the RI and risks were found to be negligible. A screening-level ecological risk assessment presented in the RI concluded that there were no significant ecological risks associated with concentrations of PCE and TCE in seeps and ditches near the Palermo neighborhood. This conclusion was reached because: (1) the measured surface-water concentrations were below ecological toxicity benchmarks and (2) aquatic receptors are not expected to be found near the points of groundwater discharge.

If contamination migrates past the Palermo Wellfield, it would likely eventually discharge to the Deschutes River, which is approximately 1,200 feet to the east of the Palermo area and is a major drainage feature for the area. The Deschutes River discharges to Capital Lake a little over 1 mile to the north of the Palermo area, and Capital Lake discharges to Puget Sound.

2.4 EXISTING DATA AND INFORMATION

The information provided in this section is intended to represent data already available from existing site documents. Interpretation included in this section is generally interpretation from the document from which the information is obtained. The optimization team's interpretation of this data is discussed in Sections 4.0 and 5.0 of this report. A cross-section summarizing the soil and groundwater results is presented in Figures 4-8 and 4-9 of the RI (Attachment A: Exhibit A-2a/b).

2.4.1 SOURCES OF CONTAMINATION

The RI and FS reports identified areas of soil contamination in three primary locations: Southgate Dry Cleaners in the Southgate Shopping Center; Brewery City Pizza located across Capitol Boulevard to the east of Southgate Shopping Center; and the Chevron service station located northeast of the intersection of Trosper Road and Second Avenue (Attachment A: Exhibit A-1). It was recognized in the RI that some of this soil contamination (such as that identified beneath Brewery City Pizza) had probably resulted from partitioning of contaminants from groundwater or soil vapor. The RI also indicated contaminated soil presence at the (current) WSDOT MTL and at the WSDOT Olympic Region Headquarters south of the Palermo Wellfield.

The RI indicates that the WSDOT MTL was a source of TCE at the site, consistent with the following information, some of which is taken from a underground storage tank (UST) Closure Report:

- Historical and recent TCE use at the facility had been documented;
- A TCE release had been documented from a UST system designed to contain spent TCE;
- TCE had been detected on the property and downgradient of the property;
- In 1996, the UST was excavated and removed from the WSDOT MTL property
- At the time of the excavation, groundwater was encountered at a depth of approximately 7.5 ft.
- The UST was full of water at the time of excavation.
- A soil sample obtained during excavation at approximately 7 ft below ground surface (bgs) indicated the presence of TCE at a concentration 0.085 mg/kg; this sample was taken between the bottom of the UST and a subsurface concrete slab located approximately 8 ft bgs.

Per the RI, the groundwater surface in the area of the WSDOT MTL is reportedly observed from 7 to 10 feet below bgs in this area. Depth to groundwater is shallow in this area due to the proximity of Barnes Lake. The depth of the UST excavation is not known. It is also unknown if any remedial measures (e.g., soil excavation and disposal) were taken during removal of the UST. Given the shallow depth to groundwater, it is feasible that the UST excavation penetrated the groundwater surface. As a result, a TCE release from the UST system could have had direct access to the groundwater surface.

At the time of the RI, FS, and ROD (1999), the Chevron station was considered to be a likely source of TCE. However, subsequent investigation led EPA to conclude that the Chevron was likely not a source of TCE for the site; accordingly since 2002, Chevron has not been considered to be a PRP at the Site. In particular, subsurface sampling at the former WSDOT MTL (south of Trosper Road), located upgradient of the Chevron station, indicated elevated TCE in the soil and groundwater (reported by URS Greiner in 2001). Also, TCE concentrations at monitoring well MW-UI, upgradient of Chevron and downgradient of the former WSDOT facility, have consistently exceeded the MCL and have been higher than concentrations at a well (MW-ES-07) just downgradient of the Chevron station.

An expert report prepared in 2006 on behalf of USEPA Region 10 (Vlassopoulos, 2006) utilized compound specific isotope analysis (CSIA) to evaluate if the TCE resulted from degradation of PCE released from the Southgate Dry Cleaners. The report concluded that the presence of TCE at the site is from upgradient of the dry cleaner and potentially related to historical operations of the former and/or current WSDOT MTL. The RI estimated the PCE release from the dry cleaner may have occurred around 1964 and the release of TCE from a location west of the dry cleaner may have occurred around 1970.

2.4.2 GEOLOGY SETTING AND HYDROGEOLOGY

The following descriptions of the site geology and hydrogeology are obtained from the RI and FS reports.

Geology of the area consists of Deschutes River fluvial deposits cutting into older glacial deposits. The glacial sediments consist of the Vashon Drift. Glacial deposits are generally flat in the uplands area with localized relief comprising Tertiary basalt or marine sandstone. Fluvial sediments in the valley are unconsolidated sands and gravels with minor silty interbeds. Fluvial deposits range in thickness from approximately 100 feet to greater than 186 feet, and the Palermo Wellfield wells are completed within these fluvial deposits (R.F. Weston 1996). Upland deposits, west of the valley, are recessional outwash deposits from the Vashon Drift. These deposits are reported to be predominantly sand. Vashon till, a dense, poorly sorted sand with variable amounts of silt and gravel, is found beneath the recessional outwash in the southwestern portion of the Deschutes River Valley. The till is reported to be absent in the uplands area west of the Palermo Wellfield. Bedrock in the study area is described as Tertiary sediments and basalt. Basalt has been identified in a boring at the Olympia Brewery at a depth of approximately 300 feet bgs and at depths greater than 350 feet bgs at other locations within the Deschutes River Valley.

Two aquifer systems are reported in the study area. The uppermost aquifer system is the Deschutes River Alluvium and the Vashon Drift. This system is considered to be unconfined (Vashon Drift in the uplands) to semiconfined (Deschutes River Alluvium in the valley). The Palermo Wellfield wells are completed within the Deschutes River Alluvium at depths ranging from 70 to 110 feet bgs. Static water levels within the Palermo Wellfield wells are generally less than 10 feet bgs. The difference in the depth to the screened water bearing zone and the depth to water in the completed wells suggests semiconfined conditions in the valley. Groundwater surface elevations in the uplands are comparable to elevations in the valley. This suggests that the Vashon Drift in the uplands is unconfined and hydraulically linked to the Deschutes River Alluvium. Groundwater flow across the study area is approximately due east with a hydraulic gradient of approximately 0.03 feet per foot with some radial flow from Barnes Lake. The modeling report in the RI presents estimates of thickness and hydraulic conductivity for the Vashon Drift/Alluvium hydrogeologic unit. Based on this information, the combined transmissivity of this unit is approximately 5,800 feet squared per day.

The lower aquifer is identified as the Penultimate Drift, located beneath the interglacial, finegrained deposits of the Kitsap Formation. The Kitsap Formation is reportedly a confining layer to the Penultimate Drift. Static water levels for wells completed within the Penultimate Drift have been reported ranging from 100 feet bgs to hydraulic heads above the ground surface. All of the site wells are completed in the uppermost aquifer system.

Depth to water in the upland site wells appears to be approximately 35 to 55 feet bgs. Depth to water in the valley site wells appears to be approximately 4 to 8 feet bgs with scattered artesian conditions observed near the base of the bluff.

2.4.3 SOIL CONTAMINATION

Soil sampling with direct-push and monitoring well installation was conducted at several potential source areas during the RI. The results of these samples as summarized by the RI are presented below. With the exception of the SVE remedy conducted at the Southgate Dry Cleaners (described later), the sampling described below is the only soil sampling documented for potential source areas.

Southgate Shopping Center Area

PCE was detected in 111 of the 176 soil samples analyzed in the Southgate Shopping Center area, at concentrations ranging from 0.001 to 258 mg/kg. The highest PCE concentration in the Southgate Shopping Center area and in the entire site was detected in the soil sample collected from beneath a dry well located in the floor of the Southgate Dry Cleaners (HA01) at a depth of approximately 4 feet bgs. PCE was identified in soil in the Southgate Dry Cleaners area from depths of 2.5 to 45 feet bgs with an average concentration of approximately 4.9 mg/kg. The highest concentrations in soil were at depths of 17 feet bgs or less. The groundwater surface is approximately 35 to 40 feet bgs in this area.

TCE was detected in 12 of the 160 soil samples analyzed in the Southgate Shopping Center area, at concentrations ranging from 0.0016 to 1.48 mg/kg at depths ranging from 5 to 40 feet bgs. The highest concentrations were from 12 to 27 feet bgs. TCE was detected in groundwater at depths very close to the groundwater surface at several sampling locations in the Southgate area.

An investigation was conducted at the Brewery City Pizza property east of the Southgate Dry Cleaners (E&E, 1997) at in the Capitol 5000 Building area. TCE and PCE were found in groundwater. No unsaturated-zone source of TCE or PCE was indicated by the soil sampling at Brewery City Pizza, suggesting that the groundwater contamination originated from an upgradient source.

WSDOT MTL

Samples were collected immediately downgradient (east) of the property. PCE was detected in 6 of the 54 soil samples collected from the MTL at concentrations ranging from 0.00011 to 0.0042 mg/kg. PCE detections in soil occurred at depths of 5 to 15 feet bgs. TCE was detected in 4 of 54 soil samples collected from the MTL at concentrations ranging from 0.00135 to 0.012 mg/kg (average 0.00801 mg/kg). TCE detections in soil occurred at depths of 5 to15 feet bgs. A soil sample was collected from the base of an excavation during the 1996 removal of the UST that contained spent TCE. According to the RI, a TCE concentration of "85 ppb" was reported for this sample in the facility audit. The depth of the sample was not reported. A fluid sample from this UST was collected prior to removal. This fluid sample contained TCE at a concentration of 15,700 µg/L.

Chevron and Former WSDOT MTL

At the time of the RI, FS, and ROD (1999), the Chevron station was considered to be a likely source of TCE based on TCE detections in soil and groundwater at the property. However, subsequent investigation led EPA to conclude that the Chevron was likely not a source of TCE for the site; accordingly since 2002, Chevron has not been considered to be a PRP at the Site. In particular, subsurface sampling at the former WSDOT MTL (south of Trosper Road), located upgradient of the Chevron station, indicated elevated TCE in the soil and groundwater (reported by URS Greiner in 2001). Also, TCE concentrations at monitoring well MW-UI, upgradient of Chevron and downgradient of the former WSDOT facility, have consistently exceeded the MCL and have been higher than concentrations at a well (MW-ES-07) just downgradient of the Chevron station.

WSDOT Olympic Region Headquarters

The RI notes that TCE was detected in soil and groundwater samples at three locations near the WSDOT Olympic Region Headquarters south of the Palermo Wellfield. TCE was detected in soil samples from the ground surface to the groundwater surface indicating that a surface release or releases likely occurred in the immediate area of one or more of these locations. PCE was detected in only one of the 21 soil samples collected from this facility at a concentration below 0.001 mg/kg. TCE was detected in 16 of the 21 soil samples collected from this facility at concentrations ranging from 0.00068 to 0.11199 mg/kg at depths ranging from 5 to 45 feet bgs. The highest concentrations were present from depths of 20 to 45 feet bgs. The groundwater surface occurs at approximately 45 feet bgs.

The plumes depicted in site groundwater monitoring reports do not depict groundwater contamination near this facility.

2.4.4 SOIL VAPOR OR INDOOR AIR CONTAMINATION

Ambient air samples have been collected from crawlspaces and home interiors across the Palermo neighborhood beginning in 2001. A figure from the Second FYR Report showing the residential neighborhood and the location of the subdrain system and indoor air sample locations is provided as Exhibit A-3 (see Attachment A). A chart presenting the indoor air and crawlspace sample results is provided as Attachment B. No indoor air or crawlspace samples have been collected since 2008. There are 47 homes in the residential neighborhood. A total of 24 different homes have been tested. Home testing frequency is summarized below:

No samples	23 homes
One sample	2 homes
Two samples	10 homes
Three samples	2 homes
Four samples	7 homes
Five samples	3 homes

Sample events typically included both home interior and crawlspace samples, but on occasion crawlspace samples are not collected. Sample events since 2004 have met the indoor air RGs, but only eight homes have been sampled since 2004. Those eight homes are located in the down-gradient portion of the highest TCE concentrations in groundwater (from roughly the 25 to 100 µg/L TCE contour), but did not include homes located west of Rainier Avenue, including the southern two homes (5101 and 5103 SE Rainier Avenue; air-sampling locations #5 and #6) that are located within or near the 100 µg/L contour for TCE in groundwater and do not meet the ROD-specified RG for groundwater depth.

Since 2001 one indoor air sample has exceeded the 4.38 µg/m^3 RG for PCE in indoor air . The sample was taken at 206 SE N Street (air-sampling station #20) in December 2004 and the PCE concentration was 18 µg/m^3; no later samples were collected at this location. The corresponding crawlspace sample result was two orders of magnitude lower for PCE (0.17 µg/m^3). Since 2001, six indoor air samples have exceeded the 1.46 µg/m^3 RG for TCE. These TCE exceedances occurred at 220 SE O Street (air-sampling station #7: 1.8 µg/m^3), 5004 SE Rainier Avenue (air-sampling station #8: up to 3.1 µg/m^3), 206 SE O Street (air-sampling station #9: up to 3.1 µg/m^3), and 5002 SE Rainier Avenue (air-sampling station #13: 2.6 µg/m^3). For each TCE exceedance in indoor air, at least one sample was collected afterward that met the indoor air RG for TCE. One crawlspace sample exceeded the indoor air goal for PCE and four crawlspace samples exceeded the indoor air goal for TCE.

The ability to acquire a robust data set of indoor air and crawlspace sample results from across the neighborhood is dependent on gaining property owner consent and occupant cooperation. As a result, the current data set lacks consistency.

2.4.5 Groundwater Contamination

Groundwater sampling was collected from monitoring wells and direct-push drilling concurrently with the soil sampling described in Section 2.4.3. Groundwater analytical results from this sampling are discussed for the same properties presented in Section 2.4.3.

Southgate Shopping Center

During the RI, PCE detections extended from the groundwater surface at approximately 32 feet bgs to over 120 feet bgs. The highest PCE concentrations in groundwater were located from 35 to 75 feet bgs. PCE was detected in 82 of the 108 groundwater samples analyzed in the Southgate Shopping Center area at concentrations as high as 949 µg/L. TCE was detected in 50 of the 108 groundwater samples analyzed in the Southgate Shopping Center area. The highest TCE concentration (169 µg/L) in groundwater was detected in a sample collected from well MW-ES-01 at a depth of approximately 95 feet bgs. This well is located in the extreme northern portion of the Southgate Shopping Center property directly downgradient of the WSDOT MTL, suggesting that the WSDOT MTL was the principal source for the elevated TCE at this location.

WSDOT MTL

During the RI, PCE was detected in 9 of the 107 groundwater samples collected from the MTL area at concentrations as high as 34.55 µg/L and at depths ranging from 25 to 75 feet bgs. The highest PCE detection (34.55 µg/L) was detected in the groundwater sample collected downgradient of the MTL at a depth of 25 feet bgs. The remaining groundwater samples displayed PCE concentrations at or below 2 µg/L. TCE was detected in 33 of 108 groundwater samples collected from the MTL area at concentrations as high as 72.8 µg/L and at depths ranging from 13 to 75 feet bgs. The highest TCE detection in groundwater occurred at a depth of approximately 45 feet bgs and approximately 240 feet east (downgradient) of the facility. The shallowest TCE detection in groundwater (13 ft bgs) occurred immediately adjacent to the former UST position.

Chevron

During the RI, PCE was detections in groundwater in the area of the Chevron station were no higher than 2.6 µg/L. TCE was detected in 46 of the 74 groundwater samples collected from the Chevron service station area at concentrations as high as 50.8 µg/L. TCE detections occurred at depths ranging from 20 to 75 feet bgs. The highest TCE detections were generally located at depths between 20 and 35 feet bgs (upper portion of the saturated zone).

WSDOT Olympic Region Headquarters

During the RI, PCE was not detected in the 22 groundwater samples collected from this area. TCE was detected in 9 of the 22 groundwater samples collected from this area at concentrations as high as 8.6 µg/L. TCE detections occurred at depths ranging from 50 feet bgs (near the groundwater surface) to 65 feet bgs. The highest TCE detections are generally located at 50 feet bgs (upper portion of the saturated zone).

Site-Wide Groundwater Sampling

Groundwater quality data has been collected by USEPA contractors on a semiannual basis. The LTM program includes twenty-one groundwater sampling locations: fifteen monitoring wells, three shallow piezometers in the Palermo neighborhood, and three production wells in the Palermo Wellfield. Water levels are collected at the monitoring wells and piezometers. Figures from the most recent Annual Groundwater Monitoring Report are included in Attachment A as Exhibits A-4 and A-5 to show measured PCE and TCE concentrations at the LTM sampling locations in October 2010. PCE and TCE concentrations are also measured in the groundwater subdrain system at four cleanout locations as part of performance monitoring for that system. Plots illustrating PCE and TCE trends in the site monitoring wells are provided in Attachment C. Plots illustrating PCE and TCE trends in the subdrain system are provided in Attachment D.

In October 2010, only two LTM monitoring wells had measured PCE concentrations above the 5 µg/L MCL. These two wells (MW-ES-06 and MW-ES-04) are in the upland area downgradient of the Southgate dry cleaners. The maximum measured PCE concentration was 34 µg/L (MW-ES-04). PCE was not detected in the monitoring wells, piezometers, or production wells in the valley; however PCE was measured at concentrations between 5.3 µg/L and 13 µg/L in the subdrain system along the western edge of the Palermo neighborhood.

Based on October 2010 data, TCE concentrations exceed the 5 µg/L MCL at nine of the fifteen monitoring wells, all three piezometers in the Palermo neighborhood, and at TW-2 in the Palermo Wellfield. Also, the subdrain system measurements all had concentrations of TCE above the MCL. The highest measured TCE concentration in October 2010 was 130 µg/L at a monitoring well (MW-ES-09) in the southwestern portion of the Palermo neighborhood.

2.4.6 SURFACE WATER CONTAMINATION

A total of 14 surface water seep samples were collected for volatile organic compound (VOC) analysis along the base of the bluff west and south of the homes along the west side of Rainier Avenue during the RI. TCE and/or PCE were detected in nine of the 14 samples. Maximum TCE and PCE concentrations in the seep water were 60 µg/L and 45.4 µg/L, respectively, both from sample SW-107 which was collected at a point west-northwest of the house at 5003 SE Rainier Avenue (air-sampling station #4), between current piezometer locations PZ-708 and PZ-709, and west of cleanout #4 (CO4) of the subdrain. A surface water sample from a crawlspace beneath a home along the west side of Rainier Avenue, contained 115 µg/L TCE and 102 µg/L PCE, the highest concentrations found during the RI surface water sample round.

A human health risk assessment was performed as part of the RI. Exposure to seep water containing TCE and PCE was included in the risk assessment. A quantitative evaluation was performed for pathways consisting of incidental ingestion of and dermal contact with water by elementary school-age children playing in the ditches. Inhalation of air contaminants from the ditches was excluded from quantitative analysis because exposure via the ambient air pathway was assumed to be negligible. The total risk for both exposure pathways combined was calculated to be 1×10^{-7} with a hazard quotient of 0.004. The dermal contact exposure pathway was found to contribute the majority of the risk, above that posed by incidental ingestion. Seeps continue to occur west of homes along Rainier Avenue and south of homes along O Street. Current seep water is expected to contain PCE and TCE above MCL values.

Surface water sampling since the RI has historically been limited to VOCs associated with the aeration pond that collects shallow groundwater from the sub drain on the west and north sides of the Palermo neighborhood. The intent of this sampling is to ensure that surface water standards for PCE and TCE are being met at the point of discharge from the aeration pond to the nearby Deschutes River. The results indicate no exceedances of ROD goals for this sampling.

During the site visit the project team encountered what appeared to be a surface water expression of shallow groundwater emanating from the Palermo Bluff. Flowing surface water was identified in a trench beginning at the base of the bluff in the southwest corner of the Palermo neighborhood and extending east along the southern edge of the neighborhood down to the Palermo Wellfield. In addition, while walking along the base of the bluff to the west side of the Palermo neighborhood the team noted several interesting surface features including a 6” polyvinyl chloride (PVC) pipe extending down from the parking areas on top of the bluff to within a few feet of the base of the bluff and another surface water feature (low lying swamp area) just east of the PVC pipe. These features are illustrated in Attachment E. The seeps and the drainage water from the PVC pipe have not been sampled. These features are shown in the attached Photolog (Attachment F).

3.0 DESCRIPTION OF PLANNED OR EXISTING REMEDIES

The information provided in this section is intended to represent information already available from existing site documents. Interpretation included in this section is generally interpretation from the document from which the information is obtained. The optimization team's interpretation of this information and evaluation of remedy components are discussed in Sections 4.0 and 5.0 of this report.

3.1 REMEDY AND REMEDY COMPONENTS

The site remedy has consisted of several remedy components specified in the 1999 ROD and summarized in the Second FYR. Each of these components is described in the following subsections.

3.1.1 WELLHEAD TREATMENT AIR STRIPPERS

Two air-stripper towers with associated blowers, an underground clearwell, and pumps and piping were constructed as part of a removal action in advance of the ROD and were incorporated into the selected remedy. The treatment system is designed to remove TCE contamination in the water from wells TW-2, TW-4, and TW-5. It was transferred to the City for operation in April 1999. In addition to removing TCE from the City's water supply, the air-stripper system also removes natural carbon dioxide which helps to increase the pH and reduce levels of certain metals at water taps in the City's distribution system.

3.1.2 SUBDRAIN AND TREATMENT LAGOON

A subdrain system consisting of perforated PVC collection pipe in gravel was installed at the foot of the bluff to the west of the Palermo neighborhood to lower the water table in the neighborhood (see Attachment A: Exhibit A-6). The subdrain consists of a 600-foot long trunk drain, eight finger drains (each approximately 75 feet long) oriented perpendicular to the trunk drain, and several cleanouts. The total depth of the trench and cleanouts varies between approximately 7 and 8 feet bgs. Water elevation in the drain ranges from a high of 104 feet above mean sea level (amsl) at the southern end to approximately 102 feet amsl at the northern (discharge) end. Collected water flows by gravity to a set of three aeration lagoons to the west of the neighborhood with a design water elevation of 97 feet amsl. Water is treated by lagoon aeration with three 3 horsepower aerators prior to gravity discharge to the Deschutes River. The subdrain and aeration lagoons have been operating continuously since installation was completed in January 2001. Measured subdrain flow rates vary seasonally and annually, but have averaged 135 gpm over the 28 measurement events since 2001 as measured at the subdrain outfall (Station 360). Recent subdrain flow rates have been among the highest recorded, at 204 and 246 gpm in May and October 2010, respectively. The average 135 gpm flow rate from the subdrain equals 70 million gallons of shallow groundwater removed per year on average.

3.1.3 STANDING WATER EVALUATION

The 1999 ROD specified additional evaluation of potential standing water in home crawlspaces and contingent actions if standing water was present (i.e., lowering the water table or venting the crawlspaces). This evaluation is ongoing; the potential presence of standing water is evaluated during semiannual subdrain performance monitoring. If standing water is present, sampling of the standing water in the crawlspaces and performing a human health risk assessment is specified. If the risk assessment shows unacceptable risks then the remedy is to either lower the water table or vent the crawlspace, whichever is more cost effective.

3.1.4 SVE

The SVE system was constructed and tested between November 1997 and March 1998 adjacent to the Southgate Shopping Center building that contains Southgate Dry Cleaners. The system included four vapor extraction wells in the parking lot and one inside the dry cleaner. Extracted vapors were treated with granular activated carbon units and discharged through a 20-foot tall emission stack. The SVE system was operated from March 1998 through June 2000. The Second FYR includes the following information from the preliminary close out report:

> *"The SVE system began operation on March 24, 1998, and removed approximately 425 pounds of PCE before it was decommissioned in June 2000, based on comparing the results of vapor samples collected from the system at startup to those collected just prior to decommissioning. The highest concentration of PCE in soil beneath Southgate Dry Cleaners prior to remediation was 63.2 mg/kg. By applying the ratio of the PCE concentration in vapor samples at startup and just prior to decommissioning to the concentration in soils prior to remediation, an average PCE concentration remaining in soil within the area of SVE system influence is estimated at 0.013 mg/kg. This is below the soil remediation goal (RG) of 0.0858 mg/kg. However, the one confirmation soil sample collected in the same area following decommissioning of the SVE system indicated a concentration of 0.232 mg/kg PCE. This indicates the presence of isolated areas of soil beneath Southgate Dry Cleaners containing PCE concentrations still in excess of the RG and therefore requires a deed restriction on the property in accordance with the ROD."*

3.1.5 LONG-TERM GROUNDWATER MONITORING

As described in Section 2.4.5, LTM program includes semi-annual sampling of the following twenty-one groundwater sampling locations for VOCs:
- fifteen monitoring wells;
- three shallow piezometers in the Palermo neighborhood; and
- three production wells in the Palermo Wellfield.

Water levels are also collected at the monitoring wells and piezometers semi-annually.

3.1.6 MONITORING OF SUBDRAIN AND LAGOON PERFORMANCE

The performance of the subdrain system is monitored on a semi-annual basis as follows:

- Measure depth-to-water in eight subdrain cleanouts (CO1 through CO8, all located west of the homes along Rainier Avenue) and twelve peizometers (PZ-704, PZ-709, PZ-715, PZ-719 through PZ-726, PZ-728) to assess depth to groundwater.

- Measure total depth in the same eight subdrain cleanouts and in three catch basins (CB-1, CB-2, CB-3) to assess for sedimentation in the drain line and conveyance piping.
- Measure total depth of the treatment lagoon along three cross sections (A1, A2, A3) to assess for sedimentation or scouring.
- Measure flow rates and collect water samples for chemical analysis from three drain cleanouts (sample locations 357, 358 and 359 which correspond to drain cleanouts CO1, CO4 and CO6, respectively); three outfalls to the treatment lagoon (sample locations 360 – subdrain outfall, 350 – storm drain outfall, and 362 – terminus catch basin outfall); and three surface water stations near the treatment lagoon (356, 361, 364) to assess contaminant removal performance. Sample station 361 is the treatment lagoon discharge location and sample station 364 is the discharge location to the Deschutes River located approximately 2,000 feet north of the treatment lagoon. Sample station 356 is located up-stream of the treatment lagoon.

3.1.7 PUBLIC NOTICE OF CONTAMINATED GROUNDWATER

USEPA published a fact sheet in February 2001, which was sent to local well drillers and property owners. The fact sheet included an alert concerning installation of new wells in the area of contaminated groundwater. A figure was included to show the area of contamination. In addition to this public notice, the City requires that all properties within the city limits be connected to the City water supply. This requirement is a disincentive to the drilling of new private wells.

3.2 RAOS AND STANDARDS

The following RAOs and associated performance standards are identified in the ROD:

1. Clean up the groundwater aquifer. The relevant standards are MCLs (5 µg/L for both PCE and TCE).
2. Prevent ingestion of, or exposure to, groundwater containing carcinogens in excess of applicable or relevant and appropriate requirements (ARARs) and total excess cancer risk no greater than 10^{-6}. The relevant standards are MCLs (5 µg/L for PCE and TCE).
3. Prevent inhalation of chemicals of concern (COCs) via vapors from surface water in residential crawlspaces at concentrations that result in a total excess cancer risk of greater than 10^{-6}. The target indoor air values for PCE and TCE are 4.38 µg/m^3 and 1.46 µg/m^3, respectively.
4. Prevent discharge of groundwater containing PCE and TCE to the Deschutes River at concentrations in excess of ARARs or resulting in an ecological hazard index (HI) greater than 1. Discharge standards are 0.8 µg/L for PCE and 2.7 µg/L for TCE.
5. Reduce the potential for PCE in soils under the Southgate Dry Cleaners to reach the groundwater.

To achieve objective related to inhalation of vapors, a performance goal for the subdrain is to lower the water table to a depth 3 feet below the bottom of the crawlspaces. The 3-foot protective depth to groundwater is referenced in the Second FYR Report and includes a margin of error in the event crawlspace floors are 1.5 feet in depth as opposed to at grade. The depth to groundwater was based on Johnson-Ettinger modeling showing a reduction of potential inhalation risks to acceptable levels.

3.3 PERFORMANCE MONITORING PROGRAMS

The performance monitoring programs are described in Section 3.1.5 and 3.1.6 as components of the remedy.

4.0 CONCEPTUAL SITE MODEL (CSM)

This section discusses the optimization team's interpretation of existing characterization and remedy operation data and site visit observations to explain how historic events and site characteristics have led to current conditions. This CSM may differ from that described in other site documents. CSM elements discussed are based on data obtained from USEPA Region 10 and discussed in the preceding sections of this report. This section is intended to include interpretation of the CSM only. It is not intended to provide findings related to remedy performance or recommendations for improvement. The findings and recommendations are provided in Sections 5.0 and 6.0, respectively.

4.1 CSM Overview

Figure 1 is a cross-section illustration of the CSM as interpreted by the optimization team.

VOC contamination released at the surface and/or in the shallow subsurface from the Southgate Dry Cleaners and both the current and former WSDOT MTL facilities has impacted groundwater at the site. The soils are relatively permeable (described as sands) and low in organic carbon. In addition, the releases in some cases may have occurred approximately 25 years before the RI sampling occurred. These factors contributed to relatively low soil concentrations observed during the RI and may have resulted in relatively weak continuing sources of dissolved groundwater contamination in 2010 at these previously identified sources.

In the case of the WSDOT MTL, groundwater is sufficiently shallow in that area that groundwater may have been impacted by the historic release from the UST without significantly impacting unsaturated soils. In the case of the Southgate dry cleaners, substantial mass was removed with an SVE remedy. The relatively high groundwater flow rates and low organic carbon have contributed to contaminant flushing over the period of three to four decades from the time of the original releases until present. As a result, the majority of contamination associated with the original releases appears to have migrated away from the source areas and is now present in the vicinity of the Palermo neighborhood. Diffusion limited transport into and out of relatively impermeable zones in the aquifer may somewhat retard the flushing. Relatively low levels of contamination in soil that are spatially limited result in low-level fluctuating concentrations in the former source areas. The SVE system has been successful at substantially reducing the mass of contamination in soil, likely resulting in reductions in groundwater concentrations at the dry cleaner. PCE groundwater concentrations downgradient of the Southgate dry cleaner, however, remain above standards and are declining at a very slow rate, suggesting that some source material may continue to cause low level groundwater contamination or that flushing of the remaining levels of contamination is diffusion limited. This may also be the case at some of the other source areas, and existing sampling locations are insufficient to tie portions of the plume back to the potential sources.

The known extent of VOC groundwater plume is approximately 3,000 feet long and includes the Palermo Wellfield. The fate of contaminated groundwater includes surface expression as seeps in the vicinity of the Palermo neighborhood, capture by the subdrain system, extraction by the Palermo Wellfield, or potentially migration beyond the Palermo neighborhood and Palermo Wellfield. Contaminant migration pathways begin at the water table near the source areas and gradually migrate deeper as a result of regional pumping and recharge. Due the relatively eastern location of the main PCE source area

(Southgate Dry Cleaners), it is likely that the PCE has remained sufficiently shallow to be captured by the subdrain system as reflected by the PCE concentrations in the subdrain and the absence of PCE detections in groundwater downgradient of the subdrain. PCE concentrations have been decreasing in the subdrain because the PCE source was mostly removed and the PCE is being flushed from the aquifer. TCE contamination, which started migrating from sources further west, has had the opportunity to migrate slightly deeper and is more dispersed. The TCE plume core likely migrates under the subdrain. The removal of water from the subdrain and the surface expression of seeps due to the abrupt change in regional topography result in an upward gradient in the valley such that some of the deeper TCE migrates closer to the surface in the Palermo neighborhood and some is extracted by the Palermo Wellfield. TCE concentrations in the upland (area of original sources) are declining in the absence of strong continuing sources, but concentrations near the subdrain and the Palermo neighborhood may have recently peaked and are only now beginning to slowly decline. If finer sediments are present at the interface of the Vashon Drift and alluvium, diffusion limited transport into and out of these sediments could contribute to slowing concentration reductions. Shallow groundwater contaminated with TCE and PCE and/or shallow groundwater discharging to the surface represent potential VI exposures for residents in the Palermo neighborhood north of the Palermo Wellfield operated by the city of Tumwater, Washington.

4.2 CSM Details and Explanation

This section provides CSM details pertaining to key questions for the optimization evaluation. Key considerations include:

- TCE and PCE source areas, groundwater plume morphology
- Shallow groundwater and potential VI in the Palermo neighborhood
- Historical information for CSM elements

4.2.1 TCE and PCE Source Areas, Groundwater Plume Morphology

The CSM as presented by the optimization team suggests that the majority of contaminant mass may have already migrated from the source areas due to high natural groundwater flushing rates and that relatively weak residual sources are contributing a low flux of contamination to groundwater. This CSM is generally supported by decreasing TCE concentration trends in many upland monitoring wells (e.g., MW-109, MW-111, MW-ES-03, and MW-ES-05) and low-level fluctuating concentrations near the former WSDOT MTL (e.g., MW-UI and MW-ES-07). The declines to date are the result of decades of groundwater flushing in the absence of a strong continuing source. Using a hydraulic conductivity of approximately 10 feet per day (consistent with RI modeling assumptions), a hydraulic gradient of 0.03 feet per foot (measured), and an effective porosity of approximately 0.25 (reasonable assumption), the groundwater seepage velocity is over 400 feet per year, allowing for approximately 5 pore volumes of flushing of the 3,000-foot long plume over a 30 to 40 year period (e.g., from approximately 1970 to approximately 2010).

With regard to PCE and TCE in the area of the Palermo neighborhood, groundwater elevations for paired wells MW-ES-09 and MW-ES-10 indicate an upward component of groundwater flow in this area. In addition, a review of TCE results for shallow well MW-ES-09 (screen interval 20-30 feet bgs, 130 µg/L) and a nearby shallow piezometer PZ-724 (87 µg/L) are indicative of TCE contamination at shallow depths downgradient of the subdrain. Deeper wells in this same vicinity such as MW-ES-02 (screen interval 95-105 feet bgs) and MW-ES-10 (screened interval 82-92 feet bgs) have historically detected approximately one half or less (47 µg/L and 46 µg/L respectively) of the highest concentrations found at well MW-ES-09 and nearby piezometer PZ-724. The presence of TCE concentrations of approximately 30 µg/L in the subdrain, higher concentrations in the shallow zone (130 µg/L at MW-ES-09), and the upward gradient in the Palermo neighborhood suggest the likelihood that the TCE plume core (and lower concentrations at deeper intervals) migrate beneath subdrain. By contrast, PCE contamination appears to be sufficiently shallow that it is presumably discharged in the surface seeps at the base of the bluffs and captured by the subdrain.

TCE concentrations at MW-ES-09 are currently the highest observed TCE concentrations at the site and concentrations are declining slowly, indicating it will take many decades to reach MCLs in this area with the current remedial approach, even if upland sources have been removed. In addition, the higher concentrations at shallower depths (compared to wellfield pumping at deeper depths) and the position of the Palermo Wellfield south of the plume core increases likelihood that the wellfield may not provide full capture (plume capture is further discussed in Section 5.2.2).

The extents of the TCE and PCE plumes are also not well defined along the southern plume boundaries. Plume contours presented in Exhibits A-4 and A-5 are not bound by monitoring wells; however several existing wells to potentially address this data gap were identified during the site visit by visual confirmation and maps provided by City employees from the Palermo Wellfield. Some of the wells appear to be owned by the City of Tumwater and may be helpful in delineating the southern plume boundary including: CT-MW-2 (may also be known as: TUM MW-96-16) and two CT-MW wells located on Linda and Ruby Streets.

4.2.2 Shallow Groundwater and VI

Due to an abrupt drop in topography between the upland and the valley, the groundwater at the base of the bluff and east to the Palermo neighborhood discharges in surface seeps. TCE and PCE are present in the shallow groundwater at the base of the bluff. The subdrain was installed in an attempt to mitigate seeps and reduce the water table elevation. Shallow groundwater TCE concentrations in the Palermo neighborhood exceed 100 µg/L (MW-ES-09). VI associated with shallow groundwater remains a concern in the Palermo neighborhood. VI sampling results to date are presented in Section 2.4.4. Interpretation of those results is discussed further in Section 5.3.2 of this report.

4.2.3 Historical Information and CSM Elements

There are a number of site features associated with the CSM, where additional information may lead to improved remedy performance and monitoring. There may be relatively small but important preferential pathways or specific localized flow regimes that can impact remedy performance near the Palermo neighborhood.

Historical site topographic and aerial photos included as part of the EDR report provided in Attachment G were also reviewed for indication of historical land use and changes in surface features that may impact surface or shallow groundwater flow. Both the 1957 aerial photo and the 1959 topo map show distinct surface road features extending down from the bluff both north of the Palermo neighborhood (M Street) and south of the neighborhood (area just North of Linda Street extending down to the Palermo Wellfield). These surface features topographically bound the current plume depictions to the north and south. In addition the United States Geological Survey 7.5 minute topographical maps provided in the EDR report (Attachment G) provide decent site coverage from 1949, 1959, 1968, 1973, and 1981; however, the contour intervals are such that there is no obvious evidence of a drainage feature noted along the bluff. The eastern most (highest) topographic lines in these maps do have a small wiggle along the bluff southwest of the Capitol 5000 building, which is suggestive of a drainage feature. This shape however is not repeated in the two western (lower) topographic lines indicating that it is not a prominent feature along the entire bluff. It should be noted that the PVC pipe identified at the base of the bluff during the optimization site visit on August 25, 2011 is adjacent to this topographic feature (Attachment E).

In addition to site physical features, historical land use in the area is also an important CSM component. A review of historical aerial photos and topographic maps provide some detail to potential land use in the site area. There is minimal development on the top of the bluff identified in aerial photos prior to the 1957 photo. A housing area at the top of the bluff is observed in the 1959 topographic map and continues to be observed until the 1973 topographic map where minimal housing structures are again observed. The 1981 topographic map, however, calls out a trailer park in this same area. A review of the aerial photographs from this same time frame (1969 and 1973 photos provide best evidence) match the topographic maps well and show a lot of structures and elongated buildings indicative of trailer homes along the bluff. Topographic maps obtained do not extend beyond 1981, however by the 1990 aerial photo all apparent trailer home structures are gone and commercial buildings appear including the Capitol 5000 building and the Brewery City Pizza building. While historical residential and commercial land use along the bluff does not indicate operations of significance, the continued redevelopment of this area likely involved excavation, grading and other shallow surface operations that can impact shallow groundwater and surface water migration in this area.

Similarly, historical use of the former and current WSDOT MTL facilities along with their relationship to shallow stratigraphy both at these facilities and at the nearby bluff west of the Palermo neighborhood are key hydrogeologic CSM features pertaining to the question of preferential migration pathways and remedy performance. A review of aerial photos and topographic maps indicates that the current WSDOT MTL began operations between 1969 and 1973 while the 1957 aerial suggests some operations of the former WSDOT MTL.

4.3 Data Gaps

There are several data gaps in the existing CSM. These are discussed in Section 5.0.

4.4 Implications for Remedial Strategy

The implications of the CSM and above data gaps are discussed in Sections 5.0 and 6.0.

5.0 FINDINGS

The observations provided below are the interpretations of the optimization team. They are not intended to imply a deficiency in the work of the system designers, system operators, or site managers but are offered as constructive suggestions in the best interest of the USEPA and the public. These observations have the benefit of being formulated based upon operational data unavailable to the original designers. Furthermore, it is likely that site conditions and general knowledge of groundwater remediation have changed over time.

5.1 SOURCES

5.1.1 CONNECTION OF PLUMES TO SOURCES

The plume depictions in LTM reports show the high-concentration portions of the TCE and PCE plumes downgradient of the source areas. While it may be that the areas of relatively high concentration have migrated downgradient in the groundwater and the source areas are now relatively clean (as discussed in Section 4.0), additional data are needed to confirm or disprove this hypothesis.

There are no LTM concentration data near the WSDOT Testing Lab or immediately downgradient of Southgate Dry Cleaners, so separation of the TCE and PCE plumes from those sources cannot be confirmed.

The delineation of the TCE plume lacks sufficient resolution to identify potential pathways from sources to plume hot-spot areas.

5.1.2 SVE EFFECTIVENESS

The SVE system was shut down and dismantled once PCE removal rates declined to a very low rate compared to early removal rates. One confirmation soil sample was collected, but this sample did not meet the ROD goal. Remaining soil contamination may be sufficient to cause VI concerns or to act as a continuing source of dissolved groundwater contamination.

5.2 GROUNDWATER

5.2.1 PLUME DELINEATION

The definition of the groundwater plume, as presented in the LTM reports is incomplete. In particular, the northern, northeastern, and southern extents of the TCE plume (as defined by the concentration contour corresponding to the MCL) are not confirmed due to lack of available concentration data. To the north, MW-ES-01 had elevated TCE concentrations (169 µg/L) during the RI. To the northeast, the plume may extend beyond the Palermo neighborhood.

The depicted PCE plume is separated from the Southgate Dry Cleaners source area even though there are no data near that source to confirm this condition. Also, the depicted PCE plume does not extend across the valley bluff even though PCE is routinely detected above the MCL in the subdrain system that intercepts shallow groundwater.

5.2.2 PLUME CAPTURE

The ROD assumes, based mainly on numerical groundwater modeling performed during the RI, that groundwater extraction at the Palermo Wellfield does capture, and will continue to capture, the entire TCE plume. However, plume capture cannot be confirmed with the available head and concentration data set. Furthermore, the wellfield operator (City of Tumwater) is under no obligation to maintain extraction rates at levels that will ensure continued plume capture.

Plume capture can be evaluated per USEPA guidelines documented in *A Systematic Approach for Evaluation of Capture Zones at Pump and Treat Systems* (EPA 600/R-08/003). Under these guidelines, capture effectiveness is evaluated using a weight-of-evidence approach that may consider the following types of analyses:

- Review of potentiometric surface maps generated from water-level measurements;
- Review of measured concentrations in groundwater wells downgradient of extraction wells;
- Calculation the expected flow needed for capture using available estimates of aquifer transmissivity, hydraulic gradient, and plume width; and
- Numerical groundwater modeling.

Potentiometric Surface Maps

There are inadequate head data to infer a regional potentiometric surface that would be needed to establish the capture zone of Palermo Wellfield. In particular, there are no piezometers within the wellfield and regional head data are not collected/evaluated as part of the LTM program.

Concentration Trends

There have been no detections of PCE or TCE at MW-110, which is east of the Palermo neighborhood. This fact supports the hypothesis of complete plume capture at the wellfield. Additional confirmation at points north and south of MW-110 would be helpful. The near-surface (shallow) portion of the plume is the critical portion to monitor.

Groundwater Flow and Extraction

Simple calculations can be made to estimate the flow that would be needed to fully capture the plume. Such calculations are described in the USEPA guidance on capture-zone evaluation. While the calculations assume ideal and non-realistic conditions (e.g., homogeneity, two-dimensional porous-media flow, no recharge), they are informative for making initial approximations of extraction rates required for hydraulic containment.

One of the simplest calculations provides an estimate of minimum flow (Q) needed for capture of a plume of known width (w) given uniform aquifer transmissivity (T) and hydraulic gradient (J): $Q = TJw$. The aquifer transmissivity is the product of aquifer hydraulic conductivity and aquifer thickness: $T = Kb$.

For purposes of this evaluation, it is assumed that the target capture zone is the TCE plume greater than 5 µg/L. The width (w) of the target capture zone is approximately 800 ft as measured from the figure in Attachment A.

Using this same figure, the hydraulic gradient (J) in the valley is estimated to be 0.03 (10 ft head drop over approximately 330 ft distance) in the valley.

The modeling report in the RI presents estimates of thickness and hydraulic conductivity for the Vashon Drift/Alluvium hydrogeologic unit. Based on this information, the combined transmissivity of this unit is approximately 5,800 ft^2/d. It is assumed in this analysis that the Kitsap Formation limits groundwater flow from the deeper Penultimate Drift to the Palermo wells (which are screened in the alluvium).

Based on these estimates of transmissivity, hydraulic gradient, and plume width, the required flow rate to capture the TCE plume is approximately 140,000 ft^3/d, or 720 gpm. It should be noted that this flow rate is based on approximations of key parameters (particularly transmissivity) and idealized assumptions. Using a 1.5 uncertainty factor (assumed), the required flow rate could be between 500 and 1000 gpm.

The average flow rate from the Palermo Wellfield has traditionally been over 800 gpm. However, based on data received from the City, the average total production from the wellfield in 2010-2011 has been less than 400 gpm. It appears that production from Palermo has been decreasing for the past decade, with other groundwater sources (primarily the Bush Middle School Wellfield) making up a larger portion of the total City water supply. The City is evaluating ways to increase the flow rate from Palermo, including rehabilitation of TW-5 and possible replacement of TW-2.

Also, the Palermo wells are not directly downgradient of the TCE plume and are deeper than the shallower plume core (e.g., MW-ES-09), which means that a portion of the wellfield capture zone does not overlap the plume.

Based on this simplistic analysis, the amount of flow required to capture the TCE plume is similar to (perhaps greater than) the current production rate of the entire Palermo Wellfield. This line of evidence does not support a hypothesis of complete capture.

Numerical Groundwater Modeling

Numerical modeling conducted during the RI indicated complete capture of the TCE and PCE plumes by the Palermo Wellfield. The modeling used reasonable methods and assumptions and a total wellfield production rate of 840 gpm based on then-current information. The actual capture zone determined from the model results was several thousand feet wide, extending from Barnes Lake to points south of the wellfield. The TCE and PCE plumes are entirely within the model-estimated capture zone.

In general, numerical modeling of capture zones will be more accurate that simple calculations of required extraction to achieve capture (e.g. as presented above) because many of the assumptions required for the simple calculation are not required for numerical modeling.

While the numerical model results support the hypothesis of complete capture, the numerical model in the RI has not been updated to reflect current extraction rates.

Overall Assessment of Capture

Based on the above information and analysis, there is not enough evidence to conclude that capture of the TCE plume is complete. Also, USEPA currently has no control over the extraction rates at the wellfield. The highest levels of contamination that are not captured may be relatively shallow (e.g., 20 feet bgs at MW-09-ES compared to approximately 80 to 90 feet bgs for the supply wells).

5.2.3 GROUND WATER CONTAMINANT CONCENTRATIONS

As concluded in the Second FYR, natural attenuation is not a significant process at the Site. Based on concentration trends at the high-concentration monitoring wells (as presented in LTM reports), it appears that it will take several decades, or longer, to achieve MCLs for TCE and PCE in the aquifer.

5.3 SHALLOW GROUNDWATER AND VI

5.3.1 GROUNDWATER DISCHARGE TO SURFACE WATER

Based on the Draft 2010 Subdrain System and Treatment Lagoon Status Report, the subdrain system has been successful in achieving the ROD-specified performance criteria in the central portion of Rainier Avenue, but not at the south end of Rainier Avenue where artesian conditions persist, and occasionally not at the north end of the street at PZ-719. As a result, the two southern-most homes (5101 and 5103 SE Rainier Avenue; air-sample locations #5 and #6)_ overlie groundwater shallower than 1.5 feet below the base of the crawlspaces, increasing the potential for TCE and PCE concentrations in indoor air to exceed ROD indoor air goals of 1.46 $\mu g/m^3$ and 4.38 $\mu g/m^3$, respectively. Groundwater beneath the northern-most home (4901 SE Rainier Avenue; air-sampling location #1), sporadically is measured shallower than 3 feet in depth. Groundwater elevations have also been measured shallower than 3 feet in depth in other areas of the neighborhood including at well MS-ES-09 northeast of the house at 5101 SE Rainier Avenue (air sampling location #5); in the northwest corner of the neighborhood (PZ-719) in May 2010, and in the southern portion of the neighborhood (PZ-725) in May 2010. Also, during the site visit the optimization team was told of a home that operated a sump pump to remove standing water from the crawlspace beneath the home (discharge location unknown). The home is located at 301 SE N Street between air sampling locations #17 and #18. The Palermo team believes that several other instances of water in crawl spaces have been reported.

The subdrain is also not effective in eliminating the surface seeps along the base of the bluff as envisioned in the ROD.

The highest TCE detection from the October 2010 sample round was 130 µg/L at well MW-ES-09 with a depth to water of 0.33 feet below top-of-casing. TCE concentrations in shallow groundwater near the homes at 5101 and 5103 SE Rainier Avenue (air sampling locations #5 and #6) are shown to be near 100 µg/L based on TCE contours using October 2010 groundwater data.

The subdrain water quality also provides an indication of seep and shallow groundwater concentrations. PCE and TCE concentrations in shallow groundwater captured by the subdrain have trended differently since 2001. PCE concentrations have decreased significantly, presumably due to PCE source area remediation with the SVE system and continued groundwater flushing. TCE concentrations have remained relatively consistent, which a recent decrease that might be associated with a decrease in flow. Trend plots from the Draft 2010 Subdrain System and Treatment Lagoon Status Report document for monitoring (cleanout) stations 357, 358, 359 and 360 are attached, showing the reduction of TCE and

PCE concentrations with time. Figures 3-5 and 3-6 from the same report are also attached showing the decrease in PCE and TCE concentrations with time.

Shallow groundwater depth and water quality are directly tied to concerns regarding VI. Expression of contaminated seeps at the surface could also pose a risk to people working or playing near the ditches that convey the contaminated water. The risks of dermal adsorption and ingestion were considered during the RI risk assessment, but exposure to vapors for this exposure scenario was not.

5.3.2 VI Potential and Air Quality

The sporadic indoor air and crawlspace data collected to date make it difficult to establish the presence or absence of a VI pathway above ROD goals. The homes at greatest risk for VI are the two southern homes and one northern home along Rainier Avenue (street address numbers 4901, 5101, and 5103; air-sample locations #1, #5, and #6). Other homes in the southwest portion of the neighborhood that overlie the highest TCE concentrations in groundwater and homes in the east-central portion of the neighborhood that overlie groundwater near 3 feet in depth are also at risk. One of these homes on N Street is the one where a sump pump is reportedly used to address standing water (301 SE N Street; between air-sample locations #17 and #18; discharge location unknown).

Crawlspace to indoor air attenuation factors are difficult to establish due to factors including site-specific differences in building construction and resulting air exchange, and background sources within homes. Review of Palermo crawlspace and indoor air data shows attenuation factors varying from above one in a few instances to 0.01, with most from 0.1 to 1, which is within the expected crawlspace to indoor air range.

The evaluation of the potential for VI based on groundwater concentrations and depth to water is further complicated by unknown performance standards. The 1999 ROD calls for achieving Model Toxics Control Act (MTCA) values in indoor air of 1.46 $\mu g/m^3$ for TCE and 4.38 $\mu g/m^3$ for PCE by lowering the water table via a subdrain system. According to the Second FYR, 2001 changes in State MTCA default values for indoor air resulted in lower indoor air thresholds of 0.022 $\mu g/m^3$ for TCE and 0.42 $\mu g/m^3$ for PCE. This suggests that the subdrain criteria might need to be more aggressive than that suggested in the ROD. However, a comparison of observed groundwater concentrations and measured indoor air concentrations from adjacent properties (Table 7-2 of the Second FYR) indicates that the Johnson-Ettinger model may have been overly conservative in establishing the original performance criteria. The calculated surface water / shallow groundwater (ponded crawlspace water) goals for protection of indoor air are 0.027 µg/L and 0.05 µg/L for TCE and PCE, respectively, which are an order of magnitude lower than the laboratory reporting limit. Modeling performed for the ROD predicted that the average crawlspace water TCE and PCE concentrations of 19.55 µg/L TCE and 20.25 µg/L PCE would result in indoor air concentrations of 408 $\mu g/m^3$ TCE and 687 $\mu g/m^3$ PCE. Actual indoor air sample results have been two to three orders of magnitude lower than predicted values.

The potential VI pathway also exists in other areas of the Palermo Superfund site. In particular, commercial lease spaces overlying and near the Southgate dry cleaners business have not been evaluated using shallow soil vapor, sub-slab soil vapor, or indoor air sampling. Residual PCE impacts to soil and groundwater in that area could result in a VI pathway. Subslab or shallow soil vapor, and indoor air sampling would be necessary to further evaluate the potential VI pathway near the former PCE source area.

5.4 Treatment System Component Performance

5.4.1 Palermo Wellfield Air Strippers

The groundwater treatment component of the remedy (air stripping) is effective. TCE and PCE do not exceed MCLs in treated water. Furthermore, since air stripping is the City's preferred technology for pH control, the air stripping remedy adds no cost or energy use to the water-treatment plant operations at the wellfield. Air stripping is also used at the City's Bush Middle School Wellfield even though no organic contaminants are present there.

5.4.2 Subdrain System Treatment Lagoon

The treatment lagoon has been meeting performance criteria in reducing PCE and TCE concentrations in water. The Second FYR references some issues with keeping the aerators operating, but City personnel did not emphasize problems during the optimization team site visit.

5.5 Regulatory Compliance

TCE and PCE concentrations in groundwater within the plume continue to exceed MCLs and likely will exceed MCLs for many decades (or longer).

TCE and PCE are regularly reported in the treatment lagoon outfall and are occasionally detected in the receiving water outfall (to the Deschutes River) but remain below the permitted limit.

TCE and PCE are regularly detected in indoor and crawlspace air within the Palermo neighborhood but have remained below the allowable limit since December 2004 (with no data since May 2008). Most indoor air detections fall within expected background concentrations, but sampling has been inconsistent due to a variety of factors.

The commercial portion of the Superfund site has not been fully evaluated for potential VI. The Southgate Cleaners lease space and adjacent lease spaces have not been tested for VI.

5.6 Components or Processes That Account for Majority of Annual Costs

Detailed annual cost information that is representative of future costs is not available, in part because much of the remedy operation is conducted by the City as part of routine public works efforts.. For this reason, annual costs are not discussed further.

5.7 Approximate Environmental Footprints Associated with Remedy

Electricity and water usage associated with water supply well and air stripper operation are not considered as part of the remedy for footprinting purposes because the wells are operated for public water supply purposes, and the City indicates that the air strippers would operate regardless of the VOC contamination to adjust the pH of the water. The water divereted to surface water from subdrain operation likely has little affect on water resources because of the potential for that water to be expressed as a natural seep in the absence of subdrain operation. The remedy footprints for energy use, air emissions, water use, materials use, and waste generation are predominantly associated with operation of the lagoon aerators, process monitoring, and semi-annual groundwater sampling. These footprints are likely relatively small and subject to substantial uncertainty given the lack of footprint information for laboratory analysis. Due to the relatively small anticipated footprint and the uncertainty, the footprint has not been quantified for this report.

5.8 SAFETY RECORD

The site team did not report any safety concerns or incidents.

6.0 RECOMMENDATIONS

Several recommendations are provided in this section related to remedy effectiveness, cost control, technical improvement, and site closure strategy. Note that while the recommendations provide some details to consider during implementation, the recommendations are not meant to replace other, more comprehensive, planning documents such as work plans, sampling plans, and quality assurance plans.

Cost estimates provided herein have levels of certainty comparable to those done for CERCLA FSs (-30%/+50%), and these cost estimates have been prepared in a manner generally consistent with EPA 540-R-00-002, *A Guide to Developing and Documenting Cost Estimates During the Feasibility Study*, July, 2000. The costs presented do not include potential costs associated with community or public relations activities that may be conducted prior to field activities. The costs and sustainability impacts of these recommendations are summarized in Tables 6-1 and 6-2.

Additional information and analysis is needed to better define the effectiveness of the remedy in (a) containing the groundwater TCE plume and (b) preventing unacceptable risks due to VI. Several recommendations are provided in Section 6.1 to address these issues. The annual costs associated with the current remedy are low, in part because the City currently operates and maintains the treatment systems at no additional cost beyond routine public works costs. There may be an opportunity to slightly reduce future annual monitoring and maintenance costs, as identified in Section 6.2. In Section 6.3, a few ideas are presented for improving data management and presentation. Finally, recommendations related to implementation of a site closure strategy are presented in Section 6.4.

6.1 RECOMMENDATIONS TO IMPROVE EFFECTIVENESS

6.1.1 EXPAND GROUNDWATER SAMPLING TO BETTER DEFINE THE PLUMES AND TO INFORM AN UPDATED CAPTURE-ZONE EVALUATION

Additional groundwater data are needed to define and confirm the shapes of the current PCE and TCE plumes, both horizontally and vertically. An expanded sampling event is recommended that includes all of the LTM sampling points plus additional existing sampling points to better delineate the current plumes. In particular, the following additional sampling points are recommended (marked in Exhibits A-3 and A-5 in Attachment A):

- Existing shallow piezometers (as available and accessible) in the Palermo neighborhood (in addition to the three that are routinely sampled), particularly:
    - PZ-719, PZ-726, PZ-730, PZ-731, and PZ-722 to define the northern and eastern TCE plume extents;
    - PZ-720, PZ-727, PZ-722, PZ-725, and PZ-729 for additional resolution of the high-concentration portion of the TCE plume; and
    - PZ-716, PZ-712, PZ-709, and PZ-708 west of the homes to try to identify locations of high PCE and TCE at the valley bluff;
- Five wells at the WSDOT Testing Lab property: MW-102, MW-103, WSDOT-MW-1, WSDOT-MW-2, and MW-ES-11;
- Existing City of Tumwater Wells that may assist with plume delineation:

    - TW-58, which is northeast of the Palermo neighborhood;
    - TW-8, which is one of the production wells in the Palermo wellfield;
    - MW-4A and MW-4B which are northwest of the Palermo wellfield;
    - A well south of the Palermo neighborhood that may be helpful for defining the southern extent of the plumes (possibly named MW-93-03);
    - A well located on the valley bluff near the southwestern corner of the neighborhood; and
    - Wells along Linda street south of the Palemro Wellfield; and
- Groundwater seep locations near the bluff, particularly in ditches behind (east of) the home at 4905 Rainier Avenue (Air Sample Location #1) and south-southeast of the home at 5103 Rainier Avenue (Air Sample Location #6).

The actual well locations and depth details should be field verified and locations should be adjusted as needed to achieve the goal of more complete delineation.

Also, there is a well in the parking lot south of the Southgate Dry Cleaners that has not been sampled because it has been found to be damaged. If it is possible to repair the well or sample the well using alternative procedures this should be attempted because the well could be a valuable data point for establishing the southern boundary of the TCE plume.

The results from the expanded sampling event should be used to update the LTM program to focus on the wells/piezometers that provide the most important information for: (1) understanding concentration trends, and (2) ensuring plume expansion does not occur. It may be helpful to repeat expanded sampling for one or two additional rounds before setting on a new LTM program. For these additional, expanded sampling events, the wells to sample should be adjusted based on results obtained in prior sampling.

Also, the results of the first expanded sampling event should be used to determine whether additional monitoring wells are needed and, if so, where. It is likely that additional shallow (water-table) groundwater wells will be needed east of the Palermo neighborhood to (hopefully) define the eastern extent of the TCE plume. Recommended locations (subject to change based on new data) are near MW-110, near TW-58, and 300 ft south of MW-110. Also, if the well in the parking lot south of Southgate Dry Cleaners cannot be sampled, a new well should be installed to define the southern plume extent. Likewise, a new well near the location of abandoned well MW-ES-01(which had elevated TCE concentrations during the RI) will likely be helpful to establish the northern extent of the plume.

It will also helpful to install a monitoring well nest immediately downgradient of the Southgate Dry Cleaners site (southwest of MW-ES-06) to better determine whether PCE has effectively been flushed away from that source (see also Section 6.1.7); both shallow and deep monitoring points are recommended at that location to also determine TCE and PCE concentrations at depth. Similarly, if sampling data from the existing wells is unclear, an additional monitoring point at the WSDOT Testing Lab may be helpful to determine if TCE has been flushed from that source area.

In addition to the water-quality sampling mentioned above, additional water level data should be collected over a wide regional area to better define the potentiometric surface as affected by pumping at the Palermo Wellfield. This includes collection of water levels at all sampled wells, wells on the golf course east of the neighborhood/wellfield, City wells south of the TCE plume, and any other accessible wells to better define the regional potentiometric surface. If a well in the wellfield has been non-operational for a reasonable period of time, that well could valuable as a head measurement point also. Ultimately, it may be useful to install one or two piezometers within the wellfield property (e.g., between TW-5 and TW-2).

Analysis of the potentiometric surface should be performed in a low-water-demand month (October-April) and should be repeated in future years. A one-time analysis of the potentiometric surface in a high-water-demand month (July-August) would be helpful for comparison.

The estimated additional cost for each expanded sampling event is $25,000 and includes seven days of sampling at $2,500 per day plus 38 additional sample analyses (including QA) at $50 each.

If five wells are installed, the estimated cost will be $71,000. That includes $10,000 for plan development, $10,000 per well for drilling, installation, and oversight, $10,000 for an installation report, and 20 sample analyses (groundwater, soil, and QA) at $50 each.

6.1.2 UPDATE CAPTURE-ZONE ANALYSIS

A new capture zone analysis should be conducted after the next sampling event using regional head data and more spatially extensive concentration data. The capture zone analysis should include:

- Development of a regional potentiometric surface for the upper aquifer (see prior recommendation) with a graphical interpretation of the capture zone, if possible;
- Evaluation of concentrations east, northeast, and southeast of the Palermo neighborhood (downgradient from the target capture zone); and
- Numerical or analytical flow modeling of capture using the best available estimates of aquifer transmissivity and wellfield pumping.

If available, the existing (RI) groundwater model may be adapted for use in this analysis.

The optimization team estimates that the costs for a rigorous capture zone analysis with this new data would be approximately $50,000 assuming the RI groundwater model is available. This is based on an estimate of 400 hours (10 full-time person-weeks) of labor at an average labor rate of $125 for groundwater modelers, management, and clerical/drafting support. This estimate includes some minor updates to the model and recalibration, but not extensive model reconstruction.

6.1.3 RENEW AND IMPROVE INDOOR AIR SAMPLING PROGRAM IN PALERMO NEIGHBORHOOD

The sporadic indoor air and crawlspace data collected to date make it difficult to establish the presence or absence of a VI pathway above ROD goals. The homes at greatest risk for VI are the two southern homes and one northern home along Rainier Avenue (street address numbers 4901, 5101, and 5103; air sampling locations #1, #5, and #6); the homes in the southwest portion of the neighborhood that overlie the highest TCE concentrations in groundwater (which includes the two southern homes on Rainier Avenue), and homes in the east-central portion of the neighborhood that overlie groundwater near 3 feet in depth, including one home at 301 SE N Street (between air sampling stations #17 and #18), that reportedly operates a sump pump (discharge location unknown).

As a first step, a survey of crawlspace conditions should be conducted, including presence/absence of a crawlspace, crawlspace height/depth and degree of saturation, and presence/absence/condition of any vapor/moisture barrier. This should be coupled with crawlspace and indoor air sampling to better assess the VI pathway and determine if active remediation is needed for homes (see next recommendation, Section 6.1.4).

Soil vapor samples are typically collected as part of a VI assessment. However, the shallow groundwater in the neighborhood makes collecting soil vapor samples difficult to impossible because soil pores are saturated with water. In the absence of soil vapor data groundwater, crawlspace air and indoor air samples are needed. Crawlspace air and indoor air data fluctuate with weather conditions and other factors such as air exchanges in the buildings, and the potential presence of background sources. As a result several sample rounds are best when relying on crawlspace and indoor air data.

According to the Second FYR the current default WSDOE MTCA Method B indoor air cleanup levels for TCE and PCE are 0.022 $\mu g/m^3$ and 0.42 $\mu g/m^3$, respectively, which (according to MTCA assumptions) equates to a 1×10^{-6} excess cancer risk. The ROD indoor air cleanup goals for TCE and PCE are 1.46 $\mu g/m^3$ and 4.38 $\mu g/m^3$, respectively, which fall within USEPA's acceptable risk range of 1×10^{-4} to 1×10^{-6} excess cancer risk. WSDOE is presently considering updates to MTCA standards for TCE and PCE.

Published background concentrations of TCE and PCE in indoor air (June 2011 USEPA 530-R-10-001) are described as highly variable, and the range of the 50th percentile for TCE and PCE are non-detect to 1.1 $\mu g/m^3$ and non-detect to 2.2 $\mu g/m^3$, respectively. The upper ends of these background ranges exceed most of the Palermo neighborhood indoor air detections.

Regardless of the depth to shallow groundwater, the potential for VI to result in indoor air concentrations of TCE and PCE above cleanup goals remains as long as the shallow groundwater contains elevated concentrations of TCE and PCE. Some homes may not have crawlspaces and in those cases the risk for elevated indoor air concentrations of TCE and PCE may be greater, depending on construction characteristics of the slab, sealing of slab penetrations, and presence/absence/characteristics of a moisture barrier beneath the slab.

Additional periodic sampling of crawlspace air and living-space air is recommended until it is reasonably established that indoor air concentrations meet ROD goals at all houses. Modeling of indoor-air concentrations has significantly overestimated actual concentrations of PCE and TCE and should therefore not be used as a primary means of effectiveness demonstration.

Summa canisters are generally considered the standard for collecting ambient air samples for low reporting limit applications. The low-flow regulator allows an integrated sample to be collected over the sample duration (24 hours for residential applications). Other ambient air sampling approaches are available in addition to Summa canisters, although those applications are typically weighted more toward an initial stage of an investigation for a problem/no-problem evaluation as opposed to quantifying very low VOC concentrations, such as those at the Palermo site. For example, one passive diffusive sampling design under the trade name "Radiello" passively uptakes VOCs by chemical sorption, and an ambient air concentration is calculated as opposed to a simple flux. However, Summa canisters may provide more detailed low-concentration quantification. Additional research of alternate sampling approaches and costs can be performed during workplan preparation.

The approximate costs for the recommended additional air sampling are:

- $26,000 for the planning phase, including a workplan ($10,000) community survey/outreach ($10,000), and building survey ($6,000: 2-person crew at $1,500/day for four days);
- $6,000 per sample event for sampling, including four days for a 2-person crew at $1,500/day;
- $11,000 per sample event for lab analysis, assuming 25 homes sampled, 25 crawlspace samples, 35 indoor air samples (10 homes with two samples), two outdoor ambient samples, and eight duplicate samples (70 samples total) for TO-15 SIM analysis at $150/sample;
- $10,000 per sampling event for data review and reporting.

Thus, the initial sampling is expected to cost approximately $53,000. Subsequent events would not require the planning tasks and would be expected to cost $27,000 each. If a total of four annual events are conducted, the total (undiscounted) cost would be approximately $134,000. Four events should provide: (a) enough information to determine that VI is not an issue at certain homes, and (b) information sufficient to assess mitigation system performance at any homes where mitigation is needed and installed, assuming that installation occurs after the second sampling event (see next recommendation in Section 6.1.4).

6.1.4 INSTALL MITIGATION SYSTEMS IF/AS NEEDED AT NEIGHBORHOOD HOUSES

Active remediation will be necessary if indoor air TCE or PCE concentrations exceed target cleanup goals and groundwater remains shallow and impacted. Typical mitigation measures for existing residences are based on radon mitigation systems. Three candidate systems are as follows:

1) Subslab Depressurization System – This system is generally the most practical for slab-on-grade foundations where a permeable vadose (unsaturated soil) zone is present. For this system, one or two suction pits are excavated adjacent to the slab and piping extends from the pits to above the house for venting. The venting location needs to be away from windows to prevent vapors from entering the structure. A small in-line fan is used to draw air from below the slab, creating a pressure differential across the slab to prevent migration into the structure. Installation costs range from $1.00 - $2.50/ft^2 for homes (January 2007 Vapor Intrusion Pathway document, by the Interstate Technology & Regulatory Council Vapor Intrusion Team; and July 2009 Proposed Plan for Vapor Intrusion Pathway, MEW Superfund Site, Mountain View and Moffett Field, California). For a 2,000 ft^2 house installation costs would range from $2,000 - $5,000. Annual electrical costs are incurred. Limitations include clayey soils and saturated soils. The presence of crawlspaces in the Palermo neighborhood and the saturated ground conditions significantly reduce the effectiveness of this approach.

2) Submembrane Depressurization – This system is generally used when crawlspaces are present and can be accessed and where a vadose zone is present. This system has been shown to be very effective. A membrane is loosely placed across the floor of the crawlspace and sealed along the perimeter and around pipe penetrations. The membrane can be polyethylene material or plastic sheeting. An extraction pipe is placed below the membrane, extending above the house. An in-line fan creates low pressure beneath the membrane. Low permeability soils may require additional extraction locations under the membrane. Costs range from $1 - $9/ft^2 ($2,000 - $18,000 for a 2,000 ft^2 home). Higher costs are due in part to sealing cracks and penetrations in the floor. Annual electrical costs are incurred. The membrane requires monitoring to ensure it remains sealed and is not damaged.

3) Crawlspace Ventilation Causing Pressurization– This system is used in instances when the crawlspace is partially enclosed and air circulation is poor, and when the crawlspace cannot be accessed to place a depressurization membrane. Air is pushed into the crawlspace by a fan to increase crawlspace air pressure and dilute concentrations of VOCs present in the crawlspace. Soil vapor is forced away from the area of high pressure and is less likely to enter the crawlspace. Cracks and floor penetrations must be sealed to prevent short-circuiting and introduction of air from the crawlspace into the home. In cold climates water and sewer pipes in the crawlspace must be wrapped to prevent freezing. During periods of cold weather, introduction of cold air into the crawlspace may result in added heating costs for the home. Costs for these systems are not as well documented as the two common approaches discussed above. Installation costs would be expected to be on the order of $2 - $3/ft^2 for homes ($4,000 - $6,000 per home based on a

2,000 ft^2 house). This includes $750 - $1,000 for a fan and louvers, and one or two days for installation and sealing at $2,000/day for a 3-person crew.

While advantages and disadvantages of all options should be considered on a house-by-house basis, conditions in the neighborhood suggest that option 3 may be the only practicable option for mitigation (if needed) where groundwater is very shallow and crawlspace clearance is very limited. For this option, the fan can be designed based on exchanging the air volume in the crawlspace about 15 times/hour. Assuming a 1.5-foot tall crawlspace across a 2,000-sq. ft. foundation (= 3,000 cubic feet x 15 exchanges/hr/60 minutes) a 750 cfm fan would be appropriate. A smaller sized fan to achieve fewer air exchanges per hour may still provide adequate ventilation. The 750 cfm fan would be very low horsepower and electrical costs for a 1/30 HP fan should be less than $10/month. Costs for the fan and louvers for the vents would be expected to total less than $750. With sealing cracks and floor penetrations, insulating pipes, and installation, an estimate of $2 to $3/sq. ft. is reasonable. The fan must continuously operate to provide the positive air pressure and ventilation in the crawlspace. If the fan stops working, moisture could build up in the crawlspace due to the louvers preventing circulation, potentially causing an environment suitable for mold growth.

6.1.5 Evaluate Options and Practicability for Lowering the Water Table at the Bluff and throughout the Palermo Neighborhood

The subdrain system has not eliminated discharge of groundwater to the surface as envisioned in the ROD. A feasibility-level evaluation of potential methodologies to eliminate surface discharge should be undertaken. Options to consider may include (but should not be limited to):

- Installation of an additional (or expanded) subdrain system to intercept shallow groundwater before discharge; or
- Groundwater extraction from deeper intervals (~ 100 ft bgs) near the bluff, with water potentially piped to the existing Palermo wellfield treatment system (directional drilling may be considered).

The optimization team finds it more likely than not that active pumping will be needed to provide a meaningful result, particularly for reducing existing seeps and for addressing the water table in the southwestern portion of the Palermo neighborhood. The southern portion of the subdrain is the highest portion of the subdrain because adequate elevation is required to allow gravity flow through the rest of the drain to the lagoons for treatment.

In conducting this evaluation, the effect of these options on overall TCE plume capture should be estimated, especially if the capture-zone analysis (as explained in a prior recommendation, Section 6.1.2) suggests that the TCE plume is not being completely captured.

If extracted water cannot be piped to the existing Palermo wellfield system for treatment and input into the water supply, considerations will be needed to provide treatment because the existing lagoon will likely not have sufficient capacity to provide the necessary treatment. An expansion of this lagoon may be feasible.

Use of the existing numerical groundwater flow model, or a new groundwater flow model, would likely be helpful for this exercise. The evaluation may result in a conclusion that elimination of surface discharge is not practical and necessary. In this case, the remedy documentation should clearly reflect the decision to allow surface discharge.

The feasibility analysis should also reassess whether a more aggressive and active cleanup strategy is warranted in the upland areas (e.g. in source areas and areas of relatively high PCE and TCE concentrations) based on the additional data collected. Such a strategy could be considered if it would accelerate the time to attain MCLs throughout the aquifer. However, the optimization team is not optimistic that a practical and cost-effective strategy can be deployed in the upland areas due to plume size and natural aerobic conditions (which limits biodegradation potential).

The optimization team estimates that the cost for this type of analysis would be on the order of $30,000 assuming the RI model is available for use with relatively minor modifications. This is based on an estimate of 250 hours of labor at an average labor rate of $115 for engineers, scientists, modelers, management, and clerical/drafting support.

6.1.6 ASSESS VI AT SOUTHGATE SHOPPING CENTER

The commercial portion of the Superfund site has not been fully evaluated for potential VI. The Southgate Cleaners lease space and adjacent lease spaces have not been tested for VI. Sub-slab soil vapor samples and indoor air samples from the dry cleaning lease space and two adjacent lease spaces (which are close to the source area and may share the same slab foundation), and ambient outdoor air samples to assess background conditions, would provide sufficient data to evaluate whether there is a potential for VI in the Southgate Shopping Center. If the dry cleaning business is active and using PCE then an indoor air sample would not be collected at that facility because the sample result would reflect the routine chemical use in that commercial lease space.

No VI evaluation is proposed outside the existing building footprint at this time, pending results from the source area and adjacent lease space results. If the source area and adjacent lease space evaluation results indicate that VI is not a concern, then further assessment outside the building footprint should not be necessary. If sub-slab results exceed screening criteria then a broader soil vapor survey can be planned to include surrounding areas and to include sampling both sub-slab and adjacent to buildings.

The optimization team estimates that the cost for implementing this recommendation is approximately $35,000, including:

- $10,000 for a work plan, including visiting the site, selecting sample locations, preparing the work plan, and preparing the health and safety plan;
- $10,000 for field work, including coring six cores (two in each of three lease spaces) and installing six soil vapor monitoring points (6-inch long #50 mesh stainless steel screen at a depth of 1-foot beneath the base of the slab, connected to ¼-inch tubing). The vapor monitoring points are placed within a 3-inch diameter hand augered boring through a 4-inch diameter hole cored through the slab. Sand is placed around the screen and the upper portion of the borehole sealed with bentonite. A brass ball valve is connected to the tubing. A hose barb for soil vapor sampling is attached to the top of the ball valve. A utility cover is placed over the core. The vapor monitoring points are allowed to equilibrate over a minimum 2-day period prior to sampling. Field QA for sampling is assumed to be the helium shroud method. An alternative is using a Freon spray (dust off spray) along all connections. One to two days in the field for one staff member to install the probes, and one to two days in the field for two staff members to sample the probes and abandon the boreholes are assumed. Field work also includes collecting one ambient air sample inside each of the three lease spaces, and one outdoor ambient air sample. Equipment includes 1-L Summa canisters for the soil vapor samples and 6-L Summa canisters for the ambient air samples. The probe installation cost does not include local boring permit fees, if any. The cost includes project-management time and coordinating with tenants and the landowner. The cost does not include working on procuring an access agreement, if necessary.

- $5,000 in laboratory fees for six USEPA Method TO-15 direct inject for subslab VOC analyses and six helium analyses (if the helium shroud field QA method is used) using Modified ASTM Method D-1946 and four ambient air samples for SIM analyses, plus possible duplicate samples and possible repeat sampling prior to abandoning boreholes.
- $10,000 for preparation of a report presenting sample and QA protocol, tabulating results and discussing findings.

6.1.7 EVALUATE SVE EFFECTIVENESS AND IMPLEMENT CONTROLS AS NEEDED

The Southgate Dry Cleaners SVE system was shut down in June 2000 after it had removed approximately 424 lbs of PCE from the vadose zone. The system was shut down due to diminishing returns: the rate of PCE removal at the time of shutdown was very small compared to removal rates measured in the first few months of operation. At the time of shutdown, a single effectiveness-assessment soil sample was collected in the SVE area at a location near where relatively high soil concentrations had been measured prior to SVE operation. The PCE concentration in that soil sample was approximately 200 µg/kg, which exceeded the soil RG of 85.8 µg/kg.

While it is clear that the SVE action at the Southgate Dry Cleaners reduced the potential for PCE migration to groundwater, it has not been demonstrated that the SVE system met the RG. While additional soil sampling could potentially be done to confirm that most of the soil meets the RG (or the RG is met on average), such an exercise is not recommended for the short term.

Rather, it is recommended that a water-table well be installed just to the east-northeast of the PCE source area to determine if groundwater concentrations are elevated. This new well should be monitored as part of the LTM program to determine if a significant PCE source is present (i.e. increasing or high-and-stable concentration). Also, the indoor sub-slab VI-assessment sampling that is recommended for this area will help in determining if a significant mass of PCE remains in the vadose zone.

Per the ROD, unless and until it is demonstrated that vadose-zone PCE poses no threat to groundwater, deed restrictions should be placed on the Southgate Shopping Center property to prevent future actions on the property that could exacerbate transfer of PCE in soil to groundwater. Such deed restrictions would specify, for instance, that the asphalt surface (or similar low-infiltration surface) remain in place and maintained by the property owner and that a program be implemented to reduce or eliminate any water infiltration in the PCE source area. Other institutional controls may also be needed if it is determined that other exposure scenarios (e.g. involving subsurface construction work) pose potentially unacceptable risks.

The cost for well installation is included with the costs in Section 6,1.1. The cost of performing an effectiveness evaluation (desktop study) plus legal costs to implement the deed restriction are estimated to be $15,000.

6.1.8 MAKE AN AGREEMENT WITH THE CITY FOR CONTINUED OPERATION OF THE PALERMO WELLFIELD IN A MANNER NEEDED TO ENSURE CAPTURE

The City is presently under no obligation to maintain production rates at the Palermo Wellfield that ensure hydraulic containment of the TCE plume. Production-rate data provided by the City show that pumping at the wellfield has declined substantially in recent years. After completion of the capture-zone evaluation recommended above, USEPA should enter into an agreement with the City requiring operation of the wells at rates deemed sufficient for capture, provided that the required rate is within the wellfield water right of approximately 1,900 gpm as an annual average (HDR, 2011).

It is assumed that the City will be agreeable to such an agreement and that only minimal legal costs will be incurred (approximately $5,000). It should be noted that many technical and legal factors need to be considered in developing such an agreement.

If increased pumping is needed, there may be technical challenges to increasing pumping (e.g. well-screen fouling or intra-well drawdown interference) that would need to be overcome through engineering design and implementation. One or more new strategically-located extraction wells may be required. Also, mandated increased pumping could result in excess supply, especially during winter (low-demand) months. In that case, USEPA should work with the City to ensure best use of extracted groundwater and, if necessary, should ensure that any discharge of unused water occurs in a cost-effective and non-detrimental way.

Also, the City of Tumwater, together with the City of Olympia and the City of Lacey, is currently beginning a project to utilize an additional groundwater right (1,400 gpm annual average) that had belonged to a now-defunct brewery. Wells that had been used for this water right are generally east of the Palermo Wellfield. If additional groundwater extraction is needed for plume containment, it is likely that the contemplated development and extraction at wells just to the east of the Palermo neighborhood would be beneficial for containment.

6.2 RECOMMENDATIONS TO REDUCE COSTS

Annual costs for this site include only groundwater monitoring and subdrain system performance evaluations. Thus, opportunities for cost savings are limited. However, as discussed below, there is at least one opportunity to reduce annual costs.

6.2.1 REDUCE SAMPLING FREQUENCY AT SELECT MONITORING WELLS

Semi-annual sampling is presently conducted for twenty-one groundwater monitoring locations. The number of sampling points should remain about the same (but the specific locations may change) after completion of the expanded sampling events recommended in Section 6.1.1. However, for most of the LTM points, sampling frequency can be decreased. Semi-annual sampling should continue for points that are needed to establish that the plume is not expanding and for points that are used to determine concentration trends for the high-concentration portions of the plumes. For the remaining monitoring points, annual sampling is recommended.

The one-time cost to update the LTM program documents is estimated to be $5,000. The reduced frequency of sampling should save approximately $5,700 per year (2 fewer days at $2,500 each + 15 fewer samples at $50 each). The reduction in monitoring costs will not occur until the new LTM program is established, which may not occur for a year or two.

6.3 RECOMMENDATIONS FOR TECHNICAL IMPROVEMENT

A few recommendations are provided that could help in managing data associated with the Site and with assisting future evaluations.

6.3.1 Monitoring Reports

Monitoring reports should identify the well-screen elevation intervals for all wells sampled. In addition to PCE and TCE concentration contour maps, cross-section maps would be useful for showing plume shape. If data indicate significant depth variability of the plumes, and this is not clear from cross sections, plume maps for different elevations or depths may be useful.

Also, as described in Section 6.1.1, regional potentiometric surface maps should be generated, at least annually, and at least for the water table (other aquifer-specific surfaces may also be useful). These maps need to cover an area much larger than the TCE plume and coordination with the City and State agencies will likely be required. These contour maps will be useful for defining the capture zone of the Palermo Wellfield and for determining the depth to water throughout the Palermo neighborhood.

These changes should have minimal effect on annual costs.

6.3.2 Well-Flow Reporting System

Extraction rates and total extracted volumes for each well at the Palermo Wellfield should be reported on a regular basis to USEPA, no less frequently than monthly. This should have no effect on annual costs.

6.3.3 Data Management System

Data from the Site, including relevant data collected by City and State agencies and contractors, should be entered into an electronic data management system to improve data availability and accessibility. This will improve the efficiency for any future evaluations at the Site. The cost for setting up the data management system should be less than $10,000. Management of the system will require some labor, but that labor will be entirely offset by improved efficiency in annual reporting of analyses.

6.4 Considerations for Gaining Site Close Out

The effectiveness recommendations listed in Section 6.1 were selected because they are likely to be helpful in helping progress toward Site Closure. Additional closure-related recommendations are provided below.

6.4.1 Suggested Closure Strategy

The active remediation systems (wellhead air stripping and subdrain system operation) at the Site appear to be functioning and providing benefits. These remediation measures should therefore be continued.

As indicated in Sections 6.1.3 and 6.1.4, VI should be reassessed and mitigation measures should be installed if/as necessary.

As indicated in Section 6.1.5, additional measures should be evaluated for elimination of surface discharge. The possible actions include:

- No additional action
- New wells for City (deep, possibly non-vertical);
- Expanded subdrain system (e.g., using deeper and/or bigger pipes).

If the recommended capture-zone analysis indicates that the TCE plume is expanding, additional remediation measures will need to be considered to address that condition.

Once these recommendations are implemented, the path to site closure will be clearer and may only depend on continued monitoring until all RGs are met (likely decades).

6.4.2 Modify the Remedy

After implementing the recommendations of Section 6.1 (as well as recommendations from the Second FYR Report), it will likely be prudent to issue a ROD Amendment, Explanation of Significant Difference (ESD), or similar document to the update and clarify the remedial strategy and goals. In particular, the new remedy document should:

- Establish that the VI pathway is evaluated primarily using air concentration data rather than groundwater-depth and partitioning models;
- Clarify that biodegradation appears to be minimal and thus natural attenuation is not a significant component of the remedy;
- Clarify the area of the TCE plume that is under control and being managed;
- Estimate the time to achieve all cleanup goals (likely decades).

6.5 Recommendations Related to Green Remediation

The current remedy has a very low environmental footprint. No green remediation recommendations are provided.

6.6 Suggested Approach to Implementing Recommendations

The recommended order for implementing recommendations, along with estimated cost information, is provided in Table 6-1. The first step should be to conduct the expanded groundwater sampling event. Many of the additional evaluations and actions will depend on the results obtained from that event.

The overall cost effect of implementing these recommendations is expected to be an increase in costs for this site on the order of a few hundred thousand dollars (present-value). The highest costs are associated with addressing the VI pathway in the Palermo neighborhood and are quite uncertain. In the costs presented in Table 6-1, it is assumed that 2 years of air sampling will be conducted in the neighborhood, then mitigation measures will be implemented at 20 homes, then an additional 2 years of air monitoring will be conducted.

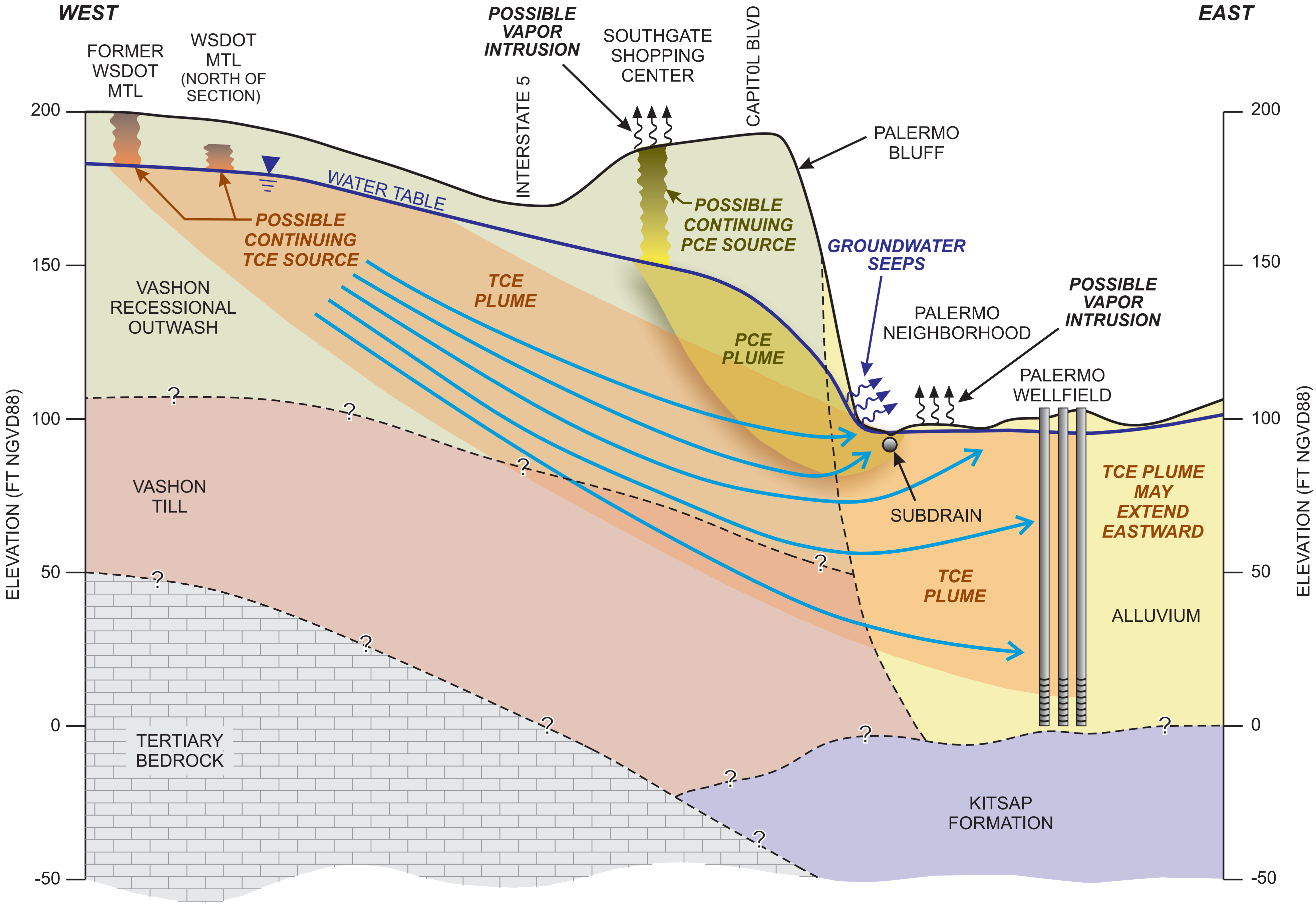
If it is determined that additional groundwater remedies are needed for plume capture or seepage control, additional costs beyond those presented here will be incurred.

Table 6-1. Cost Summary Table

Recommendation	Additional Capital costs ($)	Estimated Change in Annual Costs ($/yr)	Estimated Change in Life-Cycle Costs $*	Discounted Estimated Change in Life-Cycle Costs $**
Expanded Sampling Event (6.1.1) , assume two, six months apart	$50,000	$0	$50,000	$50,000
Implement Technical Improvement Recommendations (6.3.1-6.3.3)	$10,000	$0	$10,000	$10,000
Assess VI at Southgate Mall (6.1.6)	$35,000	$0	$35,000	$35,000
Conduct Capture-Zone Evaluation (6.1.2)	$50,000	$0	$50,000	$50,000
Install and Sample Additional Wells (6.1.1 & 6.1.7)	$71,000	$0	$71,000	$71,000
Implement Neighborhood Air Sampling Program (6.1.3), four years	$26,000	$27,000	$134,000	$126,000
Enter Agreement with City (6.1.8)	$5,000	$0	$5,000	$5,000
Evaluate SVE Effectiveness and Implement Controls (6.1.7)	$15,000	$0	$15,000	$15,000
Evaluate Options for Lowering Water Table (6.1.5)	$30,000	$0	$30,000	$30,000
Reduce LTM Frequency (6.2.1)	$5,000	($5,700)	($109,000)	($80,000)
Execute Indoor Air Mitigation (if/where needed) (4.1.4)	$100,000	$120	$102,400	$102,000
TOTAL	**$397,000**	**$21,420**	**$393,400**	**$414,000**

* Includes capital cost plus 20-years of annual cost changes (no discout rate), except neighborhood air sampling continued only for 4 years

** Dicount rate of 3% applied to annual costs

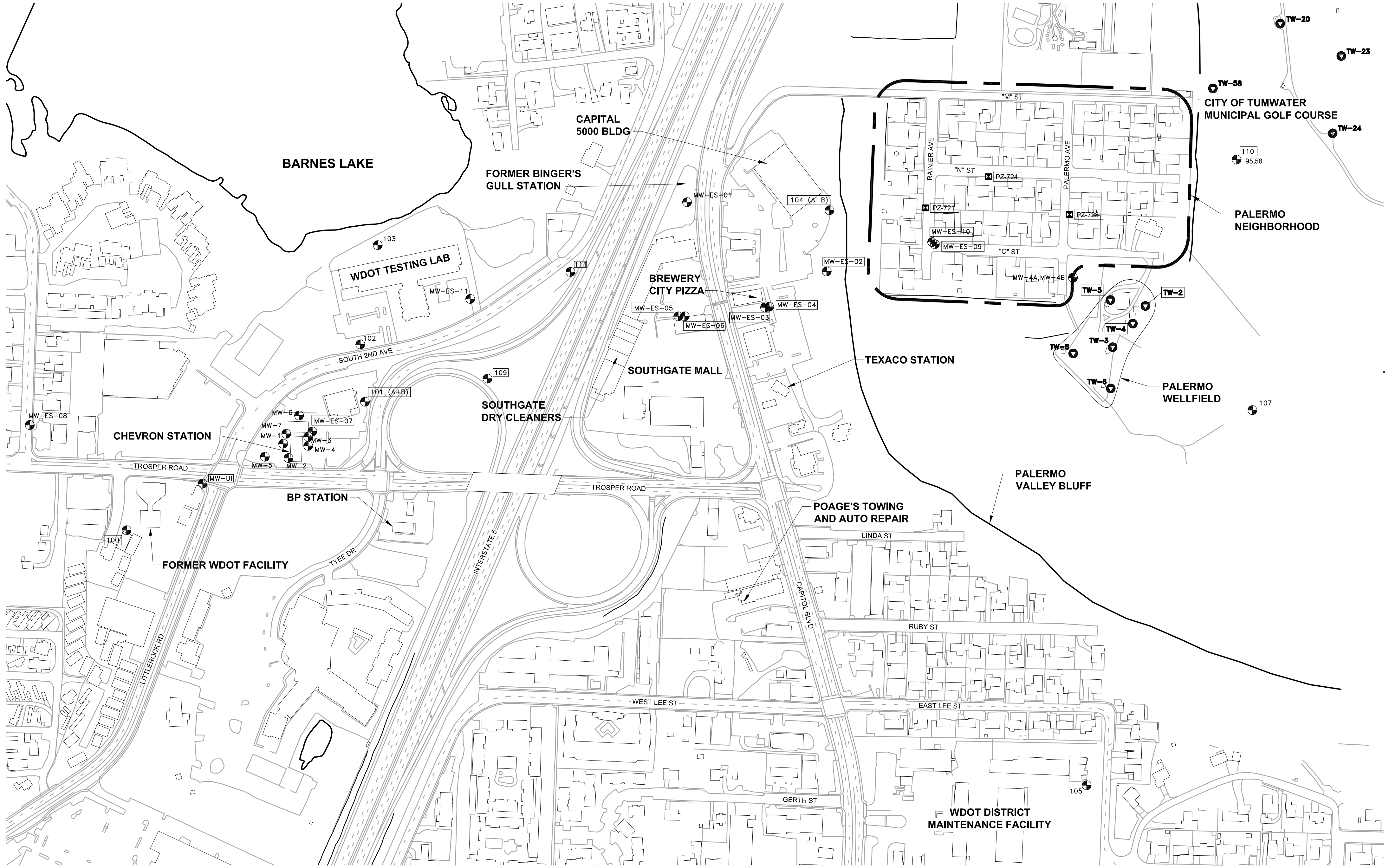


NOTE: ELEVATIONS ARE APPROXIMATE. NOT TO SCALE.

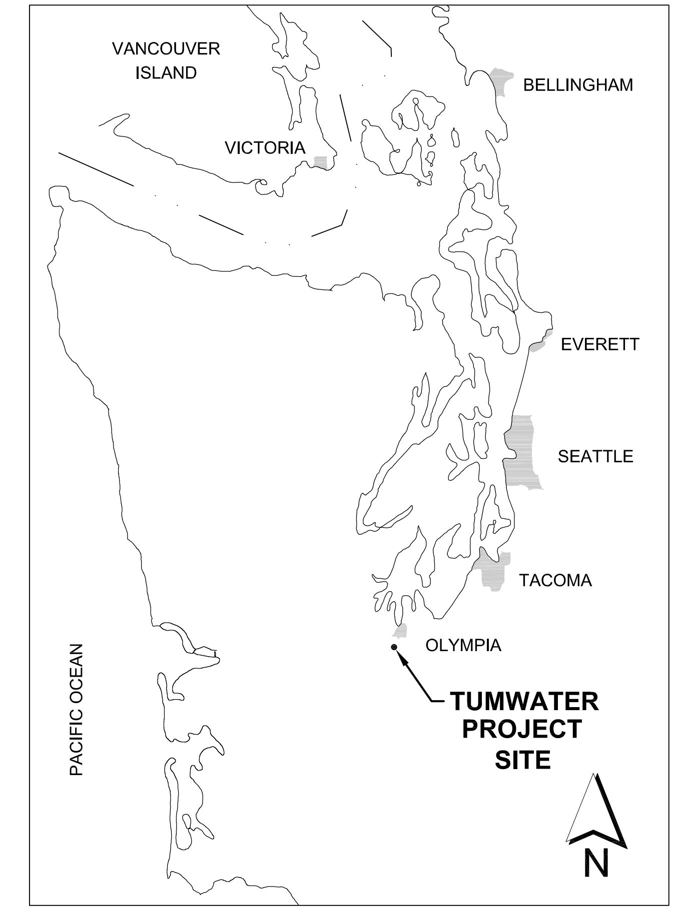
FIGURE 1
CROSS SECTION ILLUSTRATION OF SITE CONCEPTUAL MODEL
Palermo Wellfield Superfund Site

ATTACHMENT A

EXHIBIT A-1



APPROXIMATE AREA OF PALERMO WELLFIELD SUPERFUND SITE
TUMWATER, WASHINGTON



VICINITY MAP
NO SCALE

LEGEND
- ROADS/HIGHWAY
- BUILDINGS
- TW-8 DRINKING WATER WELL SAMPLED
- TW-8 DRINKING WATER WELL NOT SAMPLED
- MW-ES-05 MONITORING WELL SAMPLED
- 100 MONITORING WELL NOT SAMPLED
- PZ-721 PIEZOMETERS SAMPLED
- PIEZOMETERS NOT SAMPLED

Parametrix DATE: 10/24/08 12:29pm FILE: BR2328007P004TAN07_F1-1

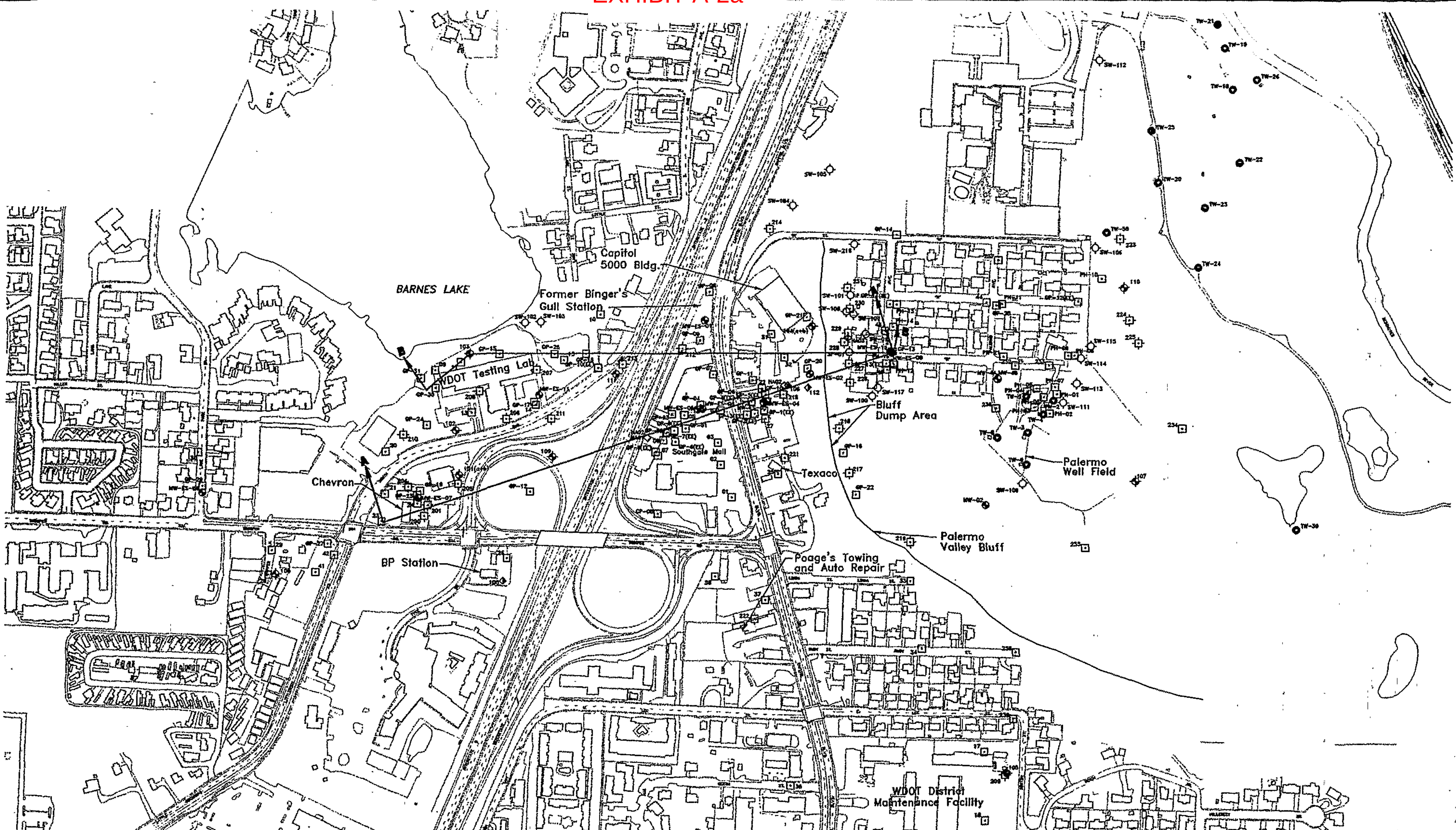
N
0 400'
SCALE IN FEET

LEGEND
PALERMO NEIGHBORHOOD BOUNDARY

SOURCE:
QUALITY ASSURANCE PROJECT PLAN
SAMPLING AND ANALYSIS FOR O&M OF SUBDRAIN SYSTEM
(URS, 2000)

Figure 1-1
Palermo Wellfield Superfund Site
Long-Term Monitoring
Project Location Map with
Monitoring Well Locations

EXHIBIT A-2a



Note: This figure was printed in color; information may be missing from black and white photocopies.

Legend

Roads/Highway	TW-8 Drinking Water Well	220 RI/FS Geoprobe Location/ID
Buildings	HA01 Hand Auger	100 RI/FS Well Location/ID
Fence	GP-05 Geoprobe	112 Soil Boring
SP-01 Surface Water/ Seep Sample	MW-ES-05 Monitoring Well	

Palermo Wellfield Superfund Site
Tumwater, WA
ARCS EPA
REGION 10

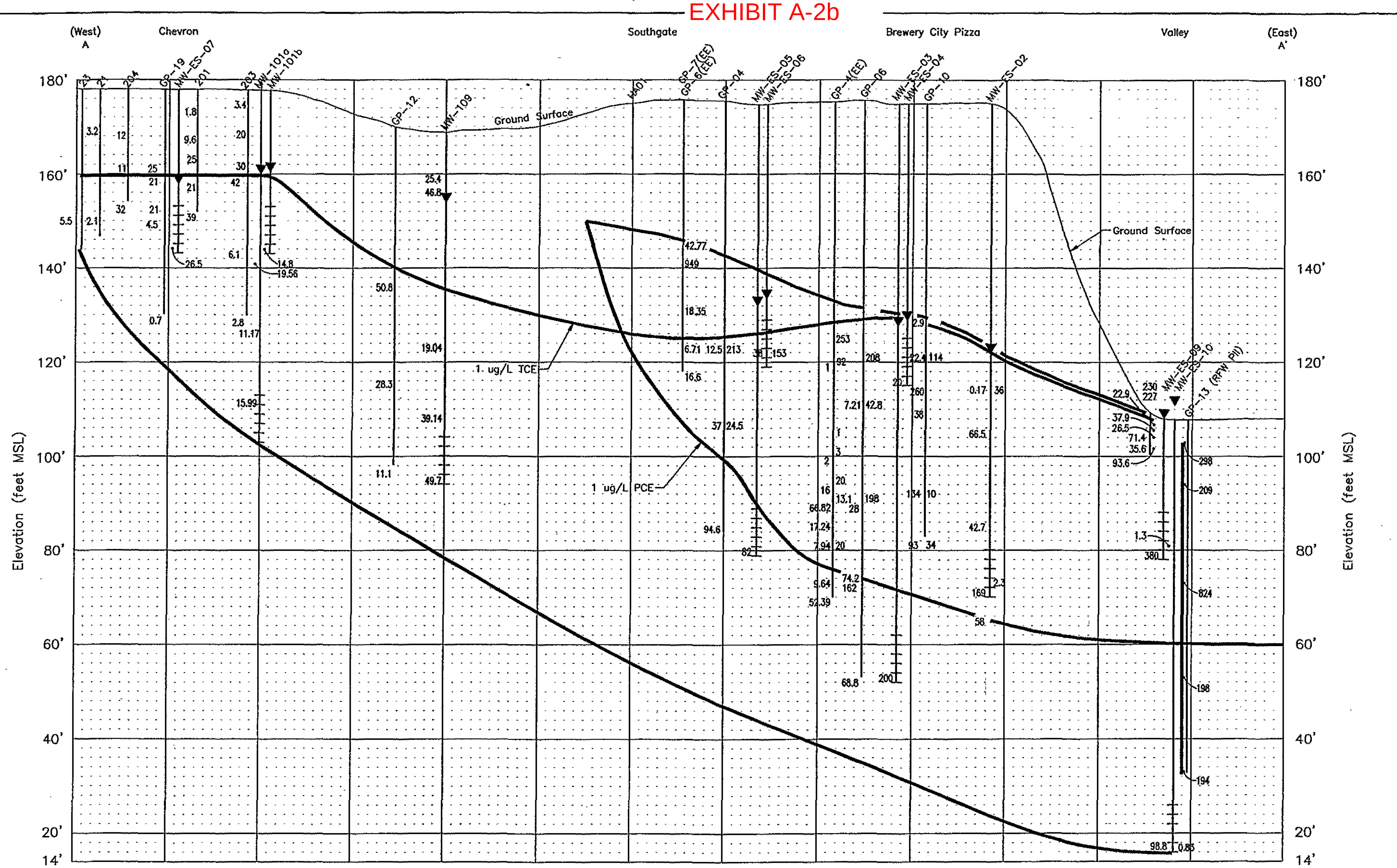
0 100 200 400
SCALE IN FEET

URS Greiner

Figure 4-8
Cross-Section Location

FILENAME: t:\Palermo\P-15.dwg
EDIT DATE: 08/28/1998 AT: 9:05

EXHIBIT A-2b



Legend

Screen Interval

Groundwater Surface May 1998

Key

	TCE	PCE
Soil (ug/kg)	TCE	
Water (ug/l)	TCE	PCE
Approximate Vertical Extent		

Palermo Wellfield Superfund Site
Tumwater, WA
ARCS EPA
REGION 10

Vertical Scale: 1"=20'
Horizontal Scale: 1"=200'

URS Greiner

Figure 4-9
Section A-A'
Showing Select PCE and TCE Soil & Groundwater Analytical Results

FILENAME: T:\Palermo\p-24.dwg
EDIT DATE: 05/12/99 AT: 10:30

EXHIBIT A-3

Parametrix DATE: 06/16/08 3:11pm FILE: B2328007P041TFR01F-03

N

0 50'

SCALE IN FEET

207 STREET ADDRESS NUMBER

PIEZOMETER TO SAMPLE FOR EXPANDED SAMPLING EVENT

PART OF EXISTING LTM NETWORK

SOURCE:
QUALITY ASSURANCE PROJECT PLAN SAMPLING AND ANALYSIS FOR O&M OF SUBDRAIN SYSTEM (URS, 2000)

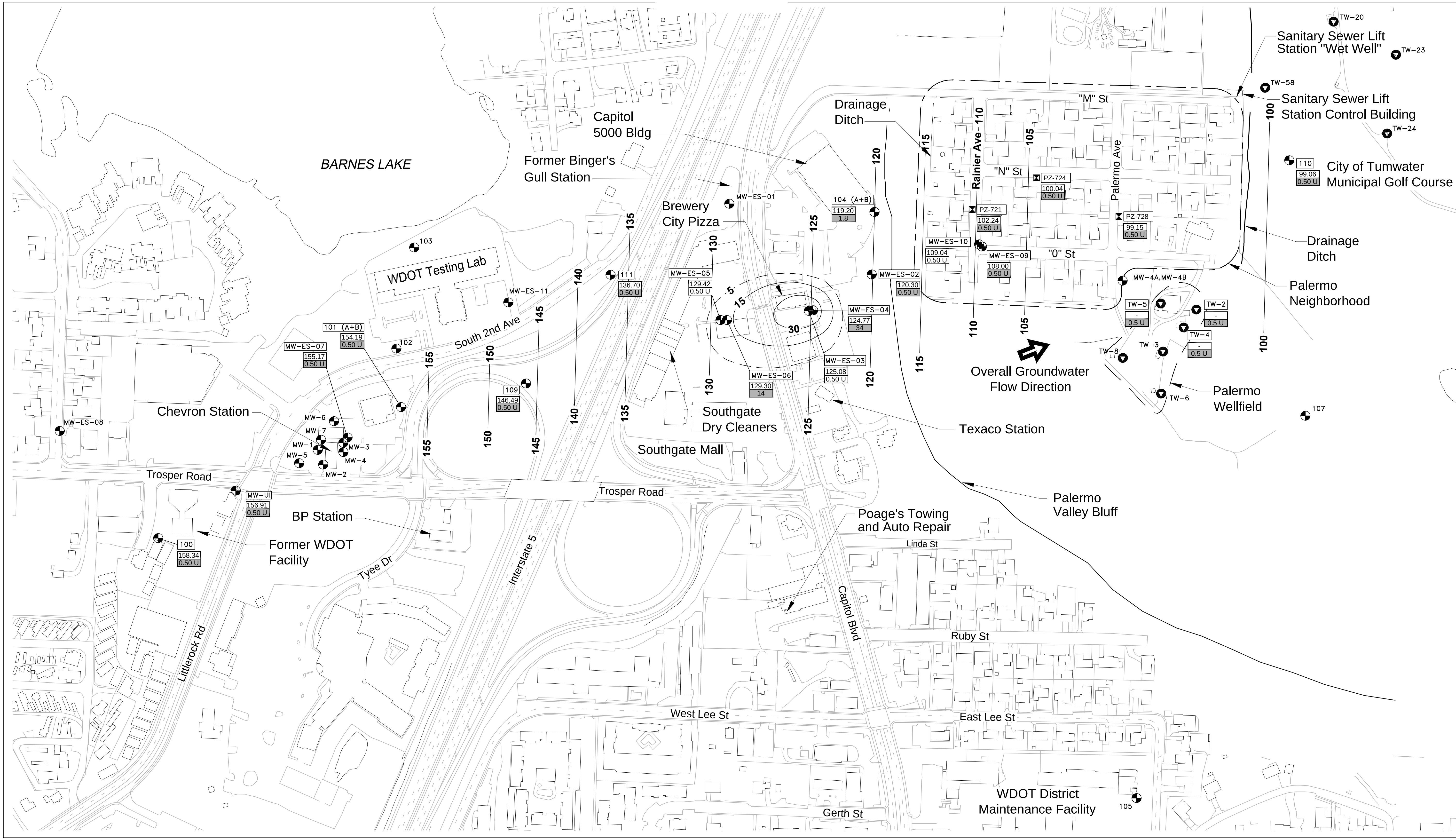
LEGEND

PIEZOMETER LOCATION

#1 INDOOR AIR SAMPLING LOCATION

Figure 7-1
Palermo Wellfield Superfund Site
Second Five-Year Review
Indoor Air Sampling Locations

EXHIBIT A-4



Parametrix DATE: 1/6/2011 10:19 AM FILE: BR2328007P004TAN07_OCT F2-3

N

0 300

SCALE IN FEET

LEGEND

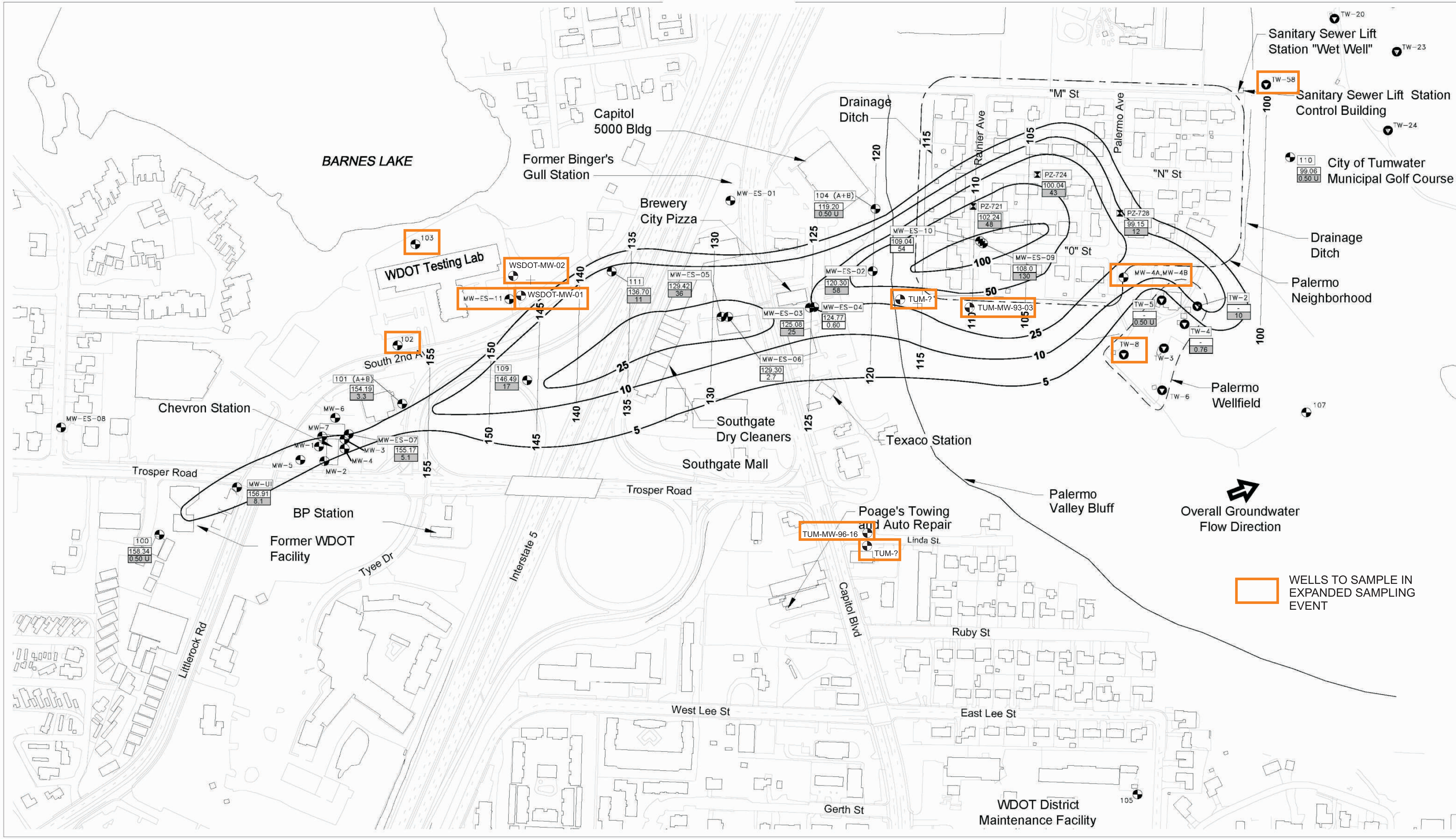
- Roads/highway
- Buildings
- TW-8 Drinking Water Well
- Piezometer
- MW-ES-05 Monitoring Well Sampled
- 100 Monitoring Well Not Sampled
- 144.28 / 0.5 U Groundwater Elevation (ft) PCE Value (ug/l)

NOTES

1. Overall Groundwater Gradient =0.015 Vertical Feet Per Linear Foot.
2. Highlighted PCE Values Used To Generate Contours.
3. PCE at concentrations exceeding 5 ug/L has been detected in the subdrain system west of Rainier Avenue. These concentrations were not included when developing the isoconcentration contour lines for PCE.

Figure 2-3
Palermo Wellfield LTM
Piezometric Contour Map with
PCE Concentrations in Groundwater
October 2010

EXHIBIT A-5



Parametrix DATE: 1/5/2011 4:28 PM FILE: BR2328007P004TAN07_OCT F2-4

N

0 300

SCALE IN FEET

LEGEND

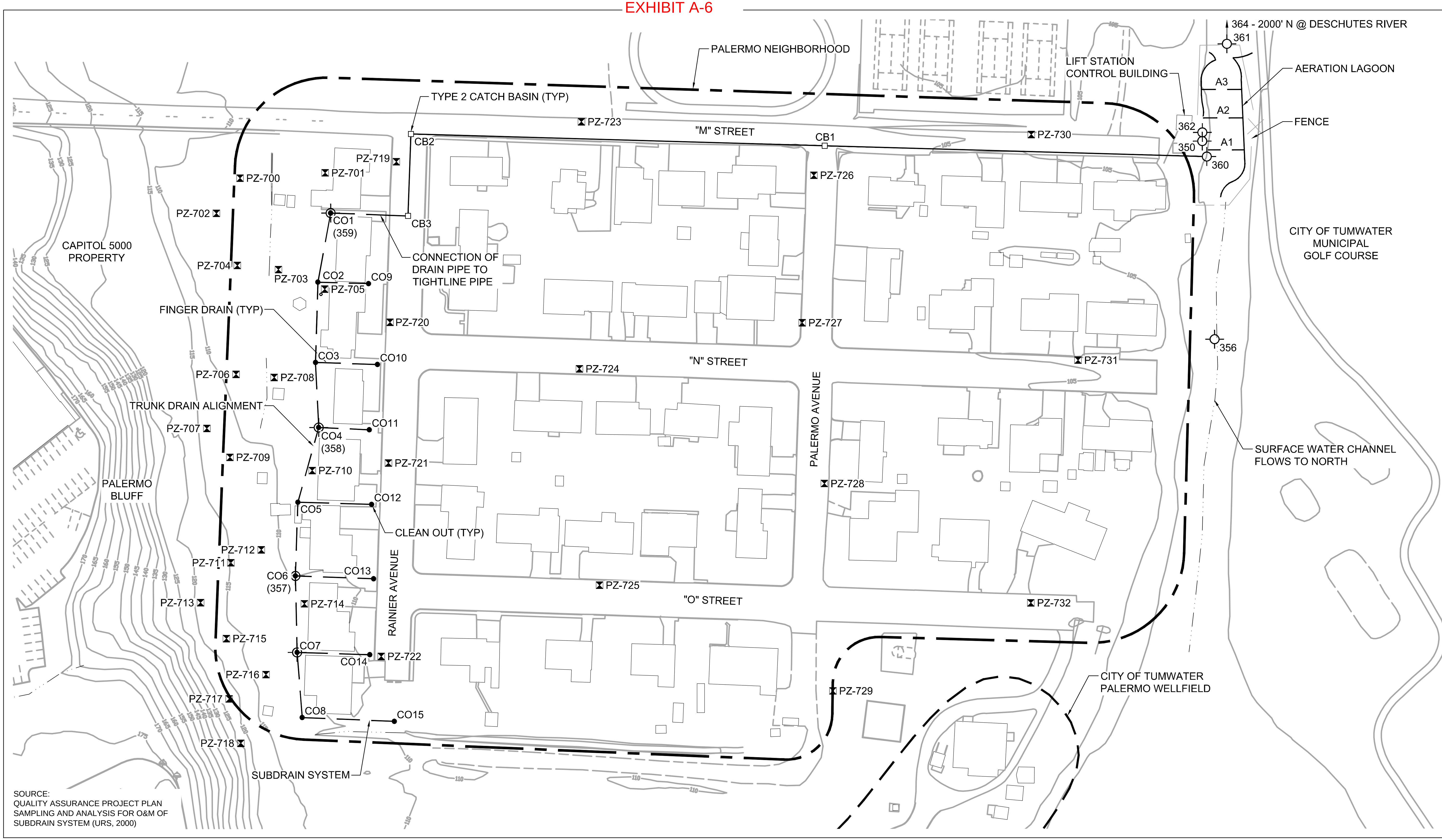
- Roads/highway
- Buildings
- TW-8 Drinking Water Well
- Piezometer
- MW-ES-05 Monitoring Well Sampled
- 100 Monitoring Well Not Sampled
- 144.28 / 0.5 U Groundwater Elevation (ft) / TCE Value (ug/l)

NOTES

1. Overall Groundwater Gradient =0.015 Vertical Feet Per Linear Foot.
2. Highlighted TCE Values Used To Generate Contours.

Figure 2-4
Palermo Wellfield LTM Piezometric Contour Map with TCE Concentrations in Groundwater October 2010

EXHIBIT A-6



Parametrix DATE: 01/12/11 11:07am FILE: BR2328007P004TAN07_F1-2

N
0 100'
SCALE IN FEET

LEGEND

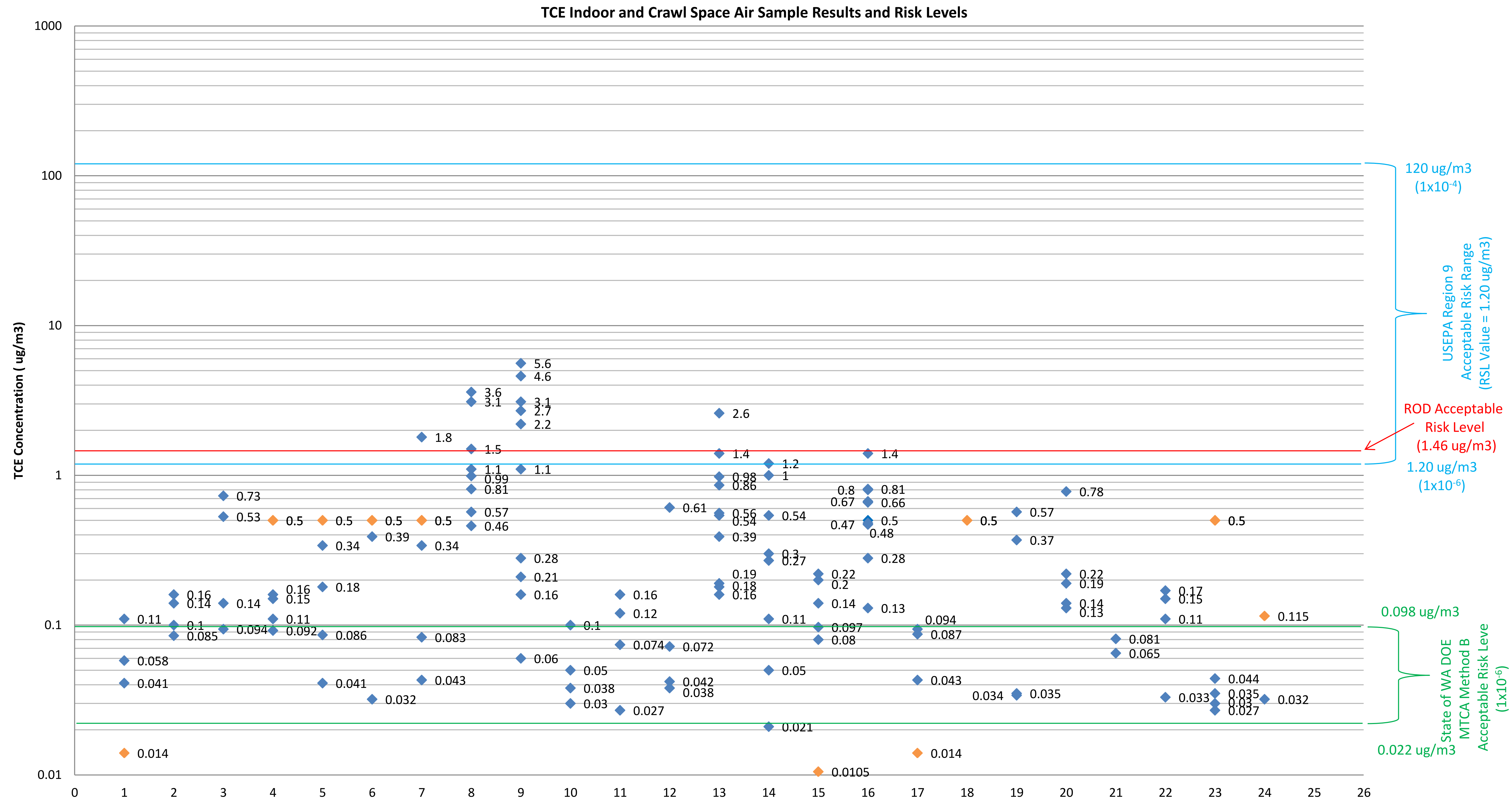
- Piezometer Location
- Water Sampling Station
- Perforated Drainpipe
- Tightline Drainpipe

SAMPLING STATION DESCRIPTIONS

350	M Street Storm Drain Outfall	359	Cleanout CO1
356	Watercourse Upstream Of Lagoon	360	Tightline Pipe Outfall
357	Cleanout CO6	361	Lagoon Effluent
358	Cleanout CO4	362	M Street Terminus CB Outfall (Rarely Flows)

Figure 1-2
Palermo Wellfield Superfund Site Subdrain System and Treatment Lagoon Status Report
System Layout and Monitoring Stations

ATTACHMENT B



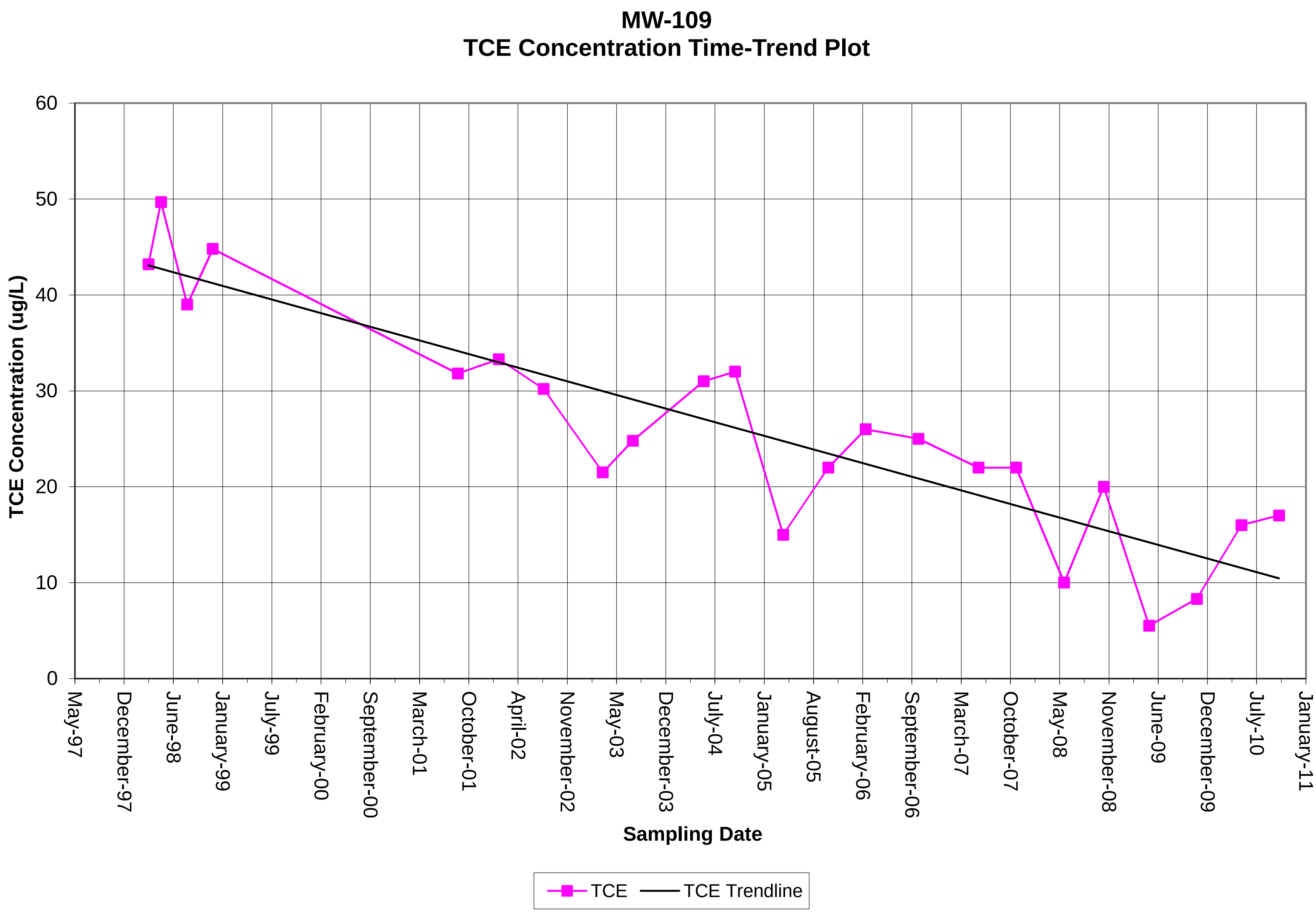
Sample results of Non-Detect (ND) are listed at half the reporting limit and marked in ORANGE

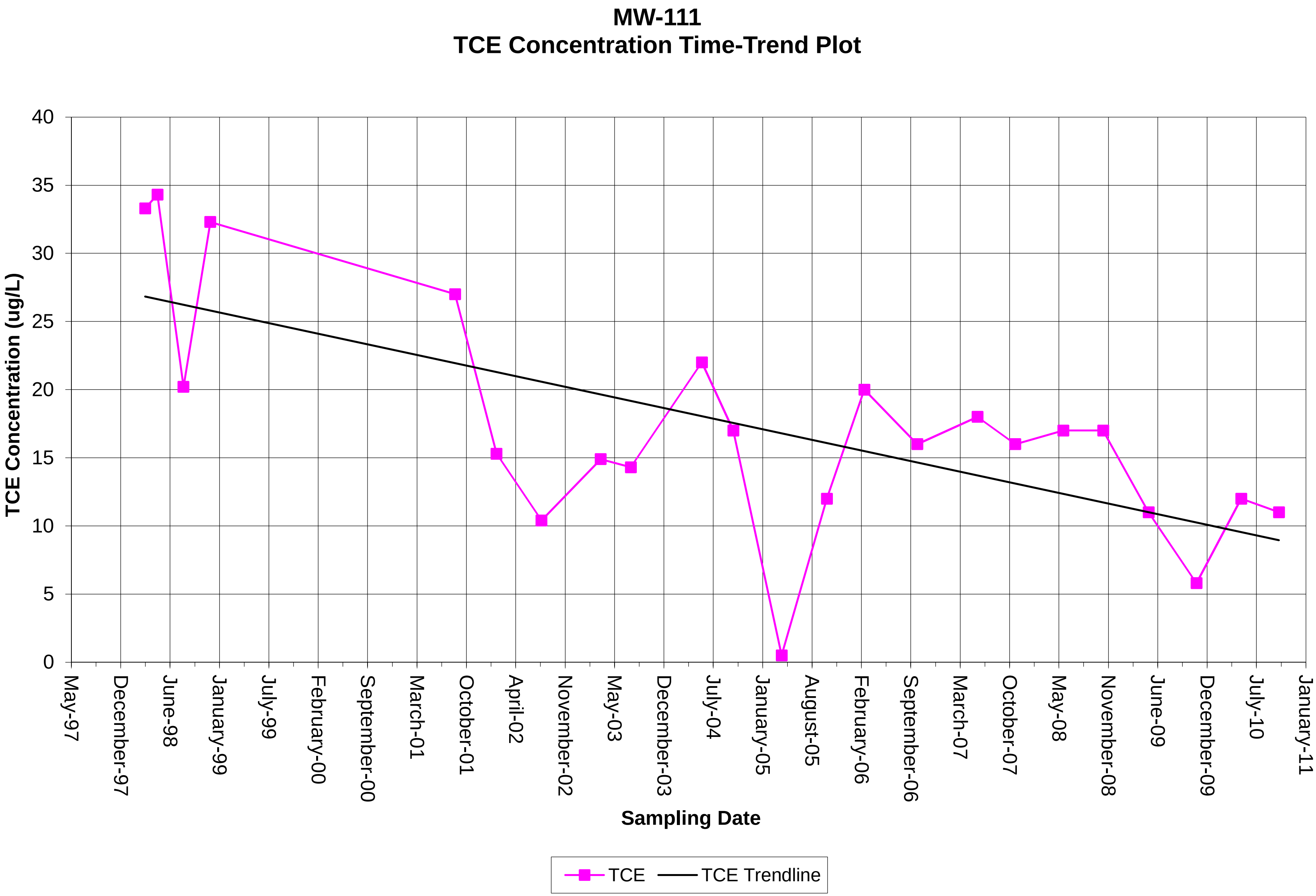
Note: Several ND results represent multiple sample events, all ND with 1.0 Reporting Limit

Note: No detections above the 1.46 ug/m3 ROD cleanup goal have been seen since 2004. All detections exceeding 1.46 ug/m3 have been followed with at least one sample event with results below 1.46 ug/m3

WA DOE MTCA Method B value is 0.022 ug/m3; revised 0.098 ug/m3 value is under consideration

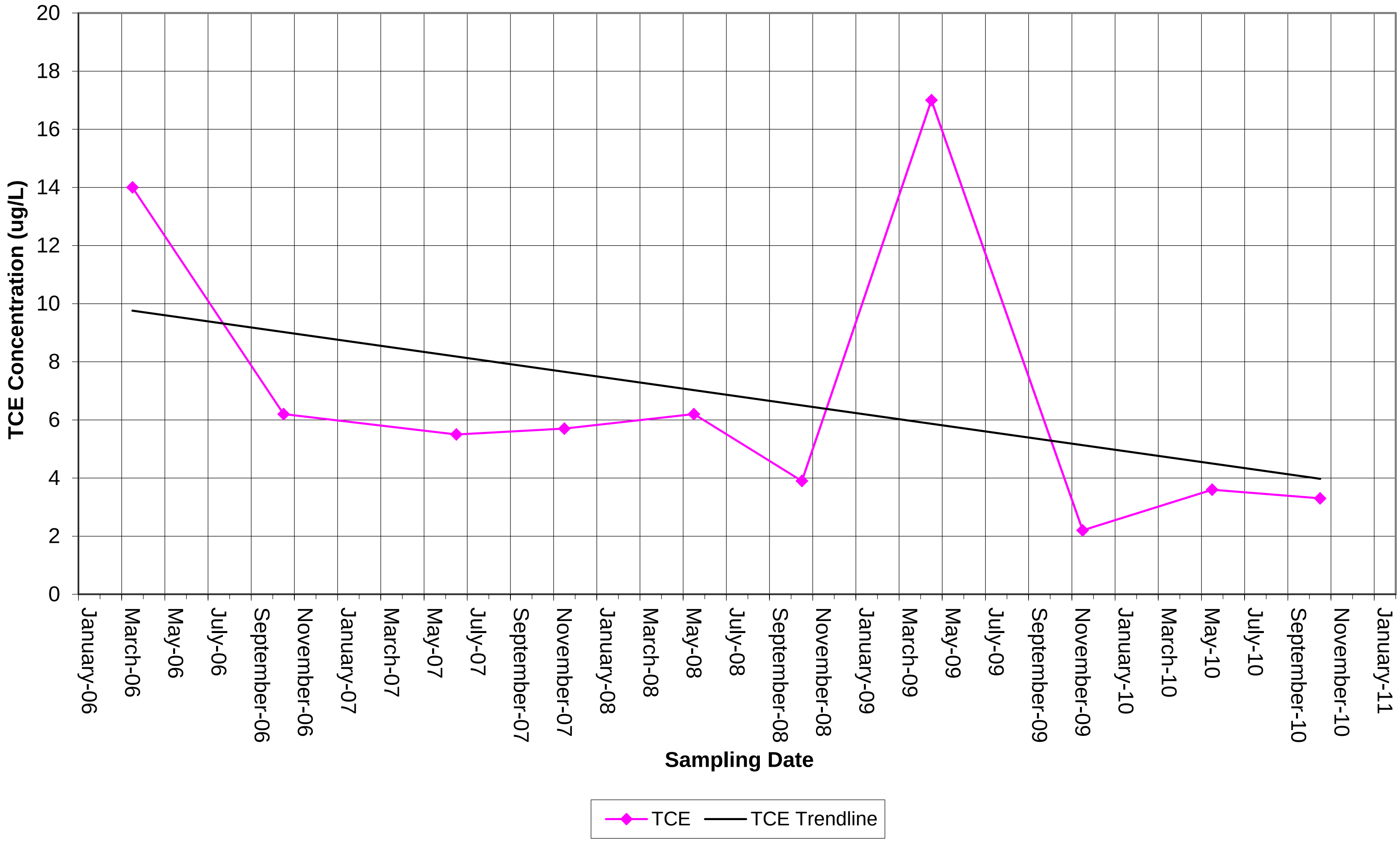
ATTACHMENT C

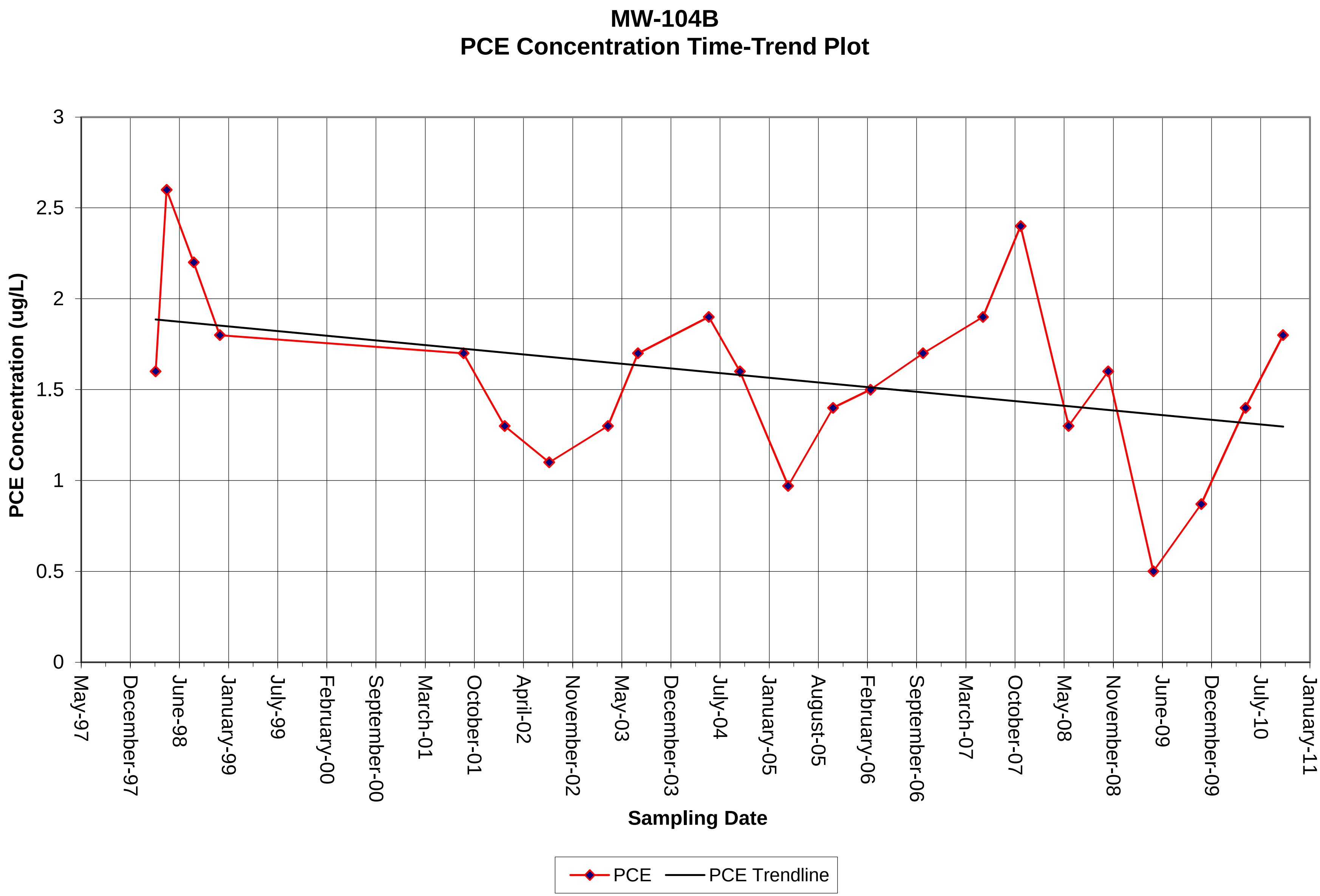

MW-109
TCE Concentration Time-Trend Plot
TCE Concentration (ug/L)
60
50
40
30
20
10
0
May-97
December-97
June-98
January-99
July-99
February-00
September-00
March-01
October-01
April-02
November-02
May-03
December-03
July-04
January-05
August-05
February-06
September-06
March-07
October-07
May-08
November-08
June-09
December-09
July-10
January-11
Sampling Date
TCE
TCE Trendline

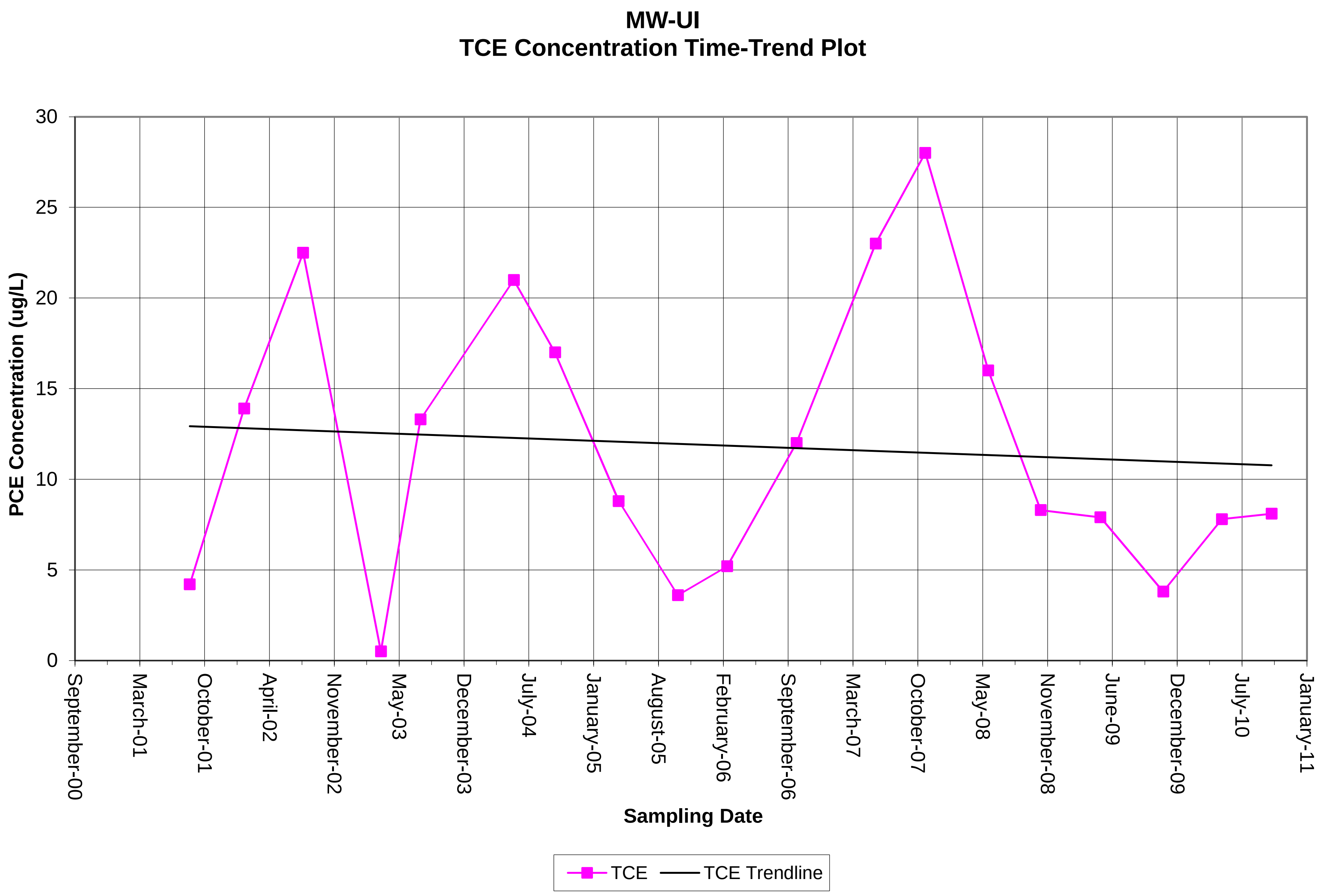


MW-111
TCE Concentration Time-Trend Plot
TCE Concentration (ug/L)
40
35
30
25
20
15
10
5
0
May-97
December-97
June-98
January-99
July-99
February-00
September-00
March-01
October-01
April-02
November-02
May-03
December-03
July-04
January-05
August-05
February-06
September-06
March-07
October-07
May-08
November-08
June-09
December-09
July-10
January-11
Sampling Date
TCE
TCE Trendline

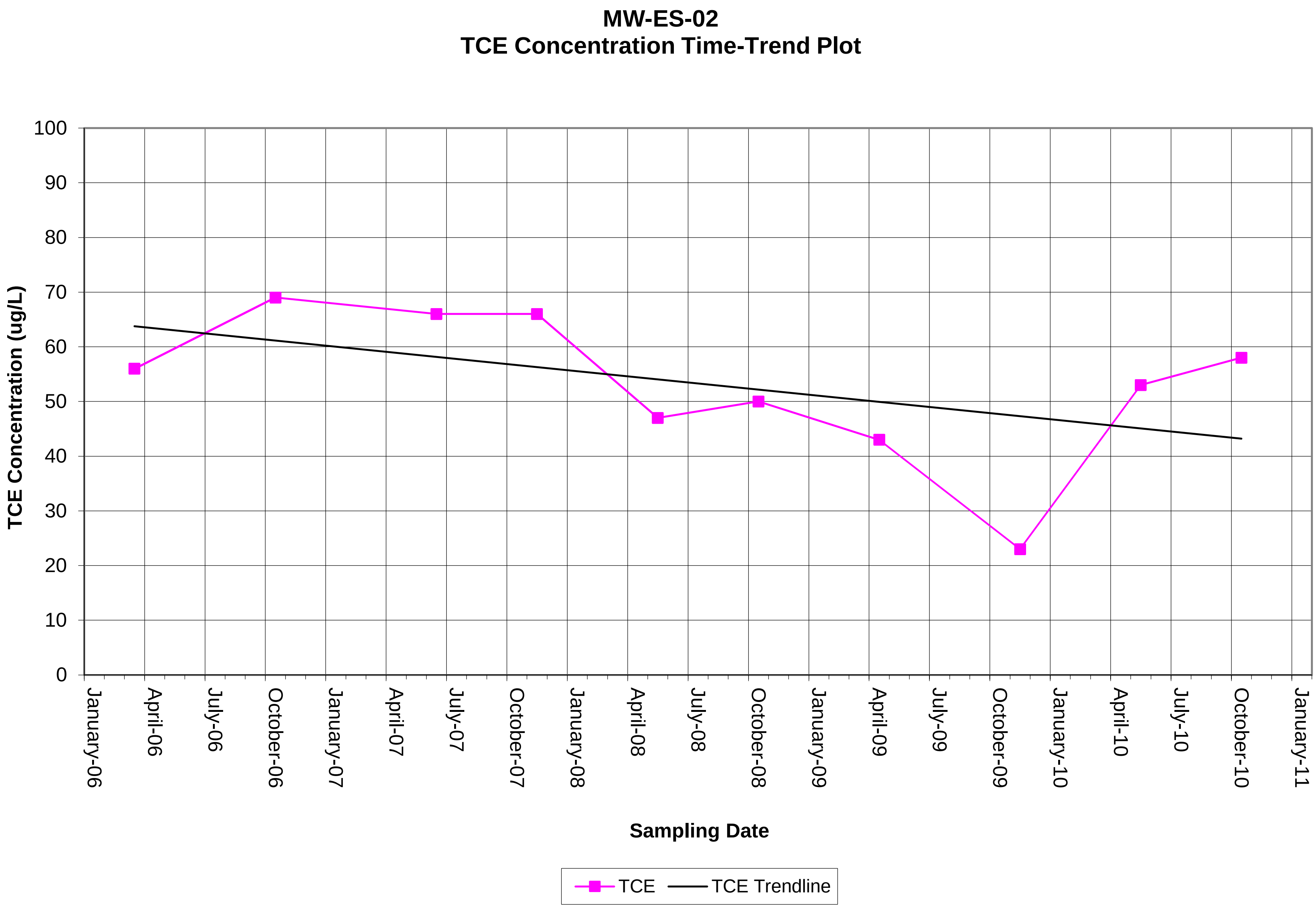
MW-101B
TCE Concentration Time-Trend Plot

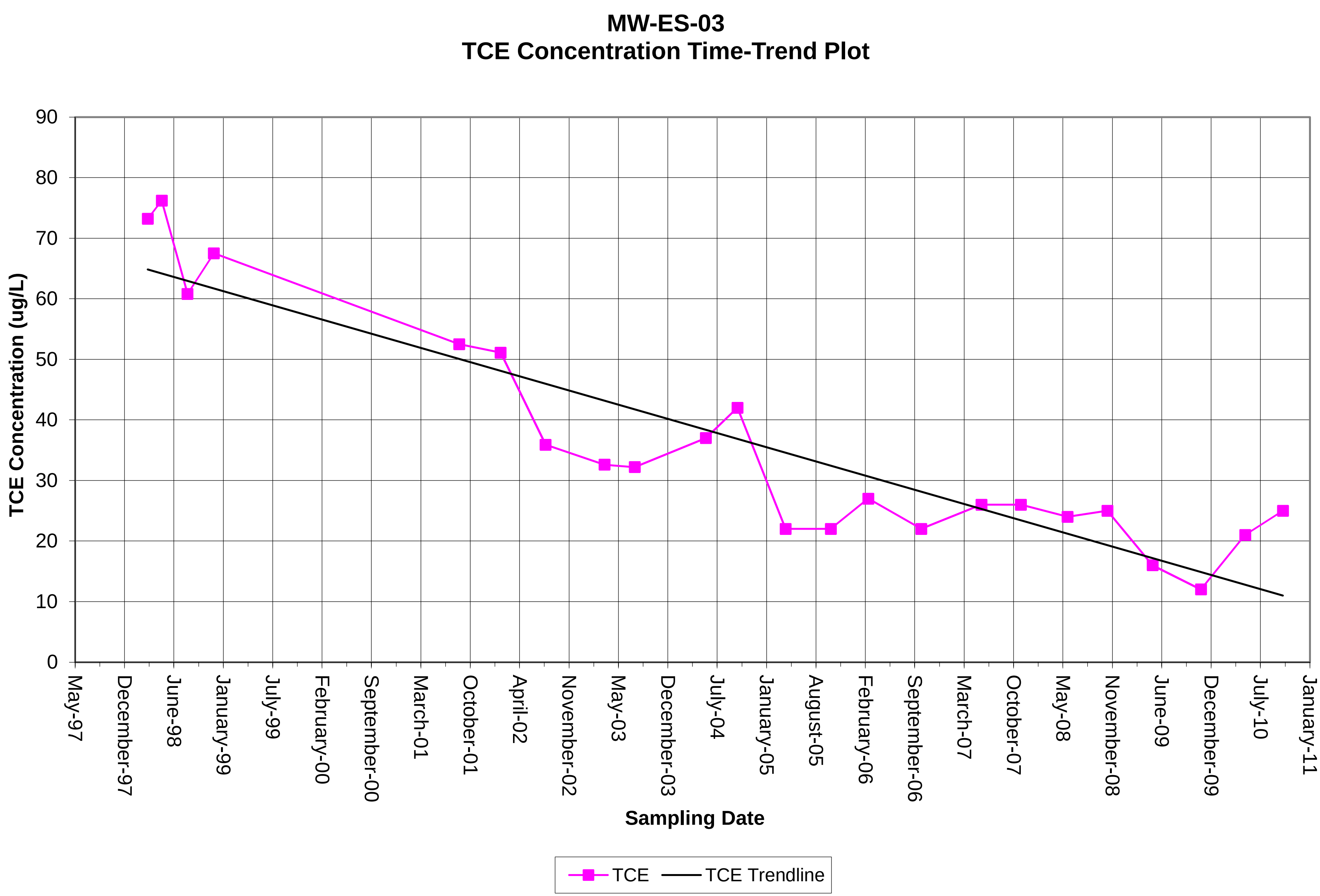


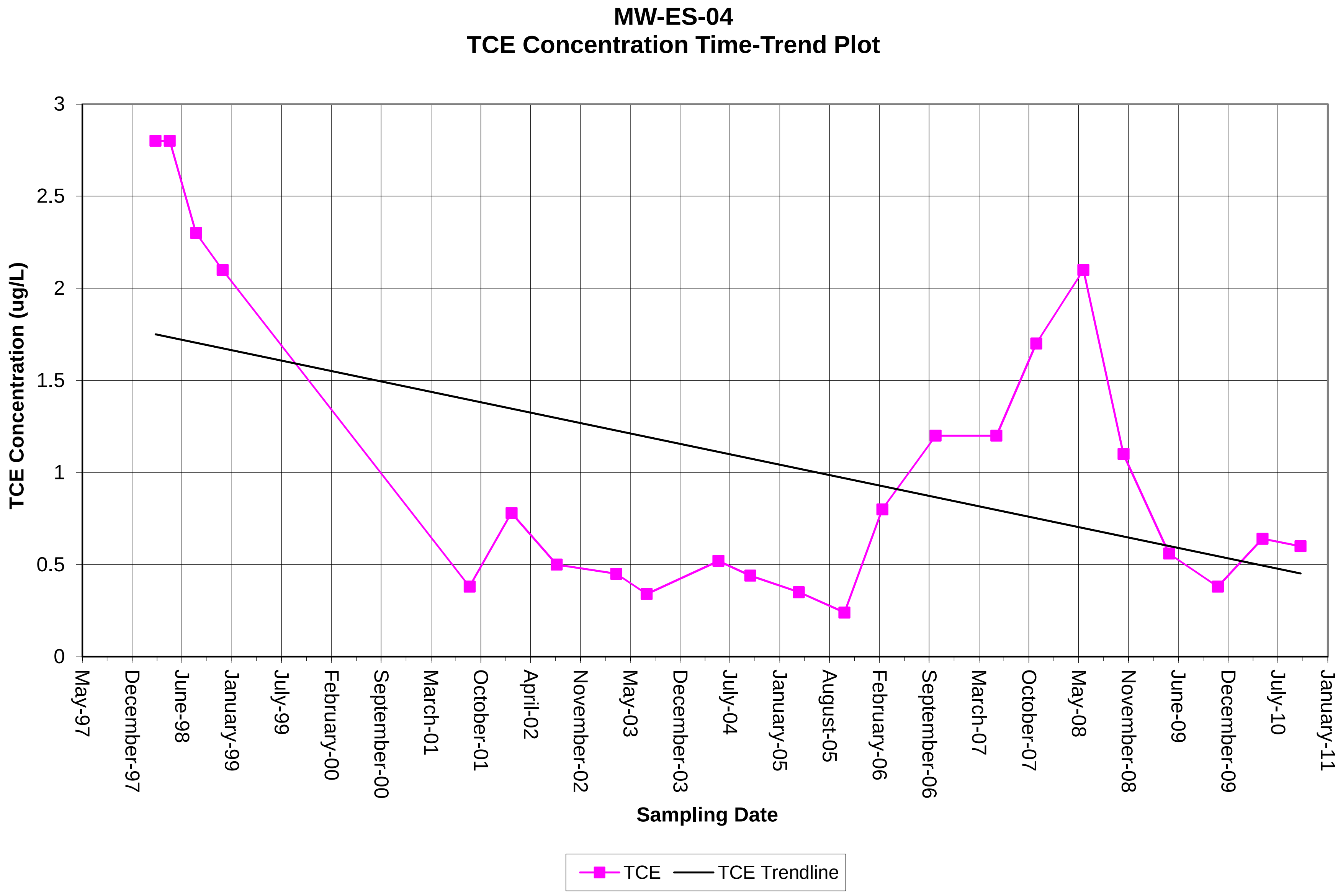

MW-104B
PCE Concentration Time-Trend Plot
PCE Concentration (ug/L)
3
2.5
2
1.5
1
0.5
0
May-97
December-97
June-98
January-99
July-99
February-00
September-00
March-01
October-01
April-02
November-02
May-03
December-03
July-04
January-05
August-05
February-06
September-06
March-07
October-07
May-08
November-08
June-09
December-09
July-10
January-11
Sampling Date
PCE
PCE Trendline



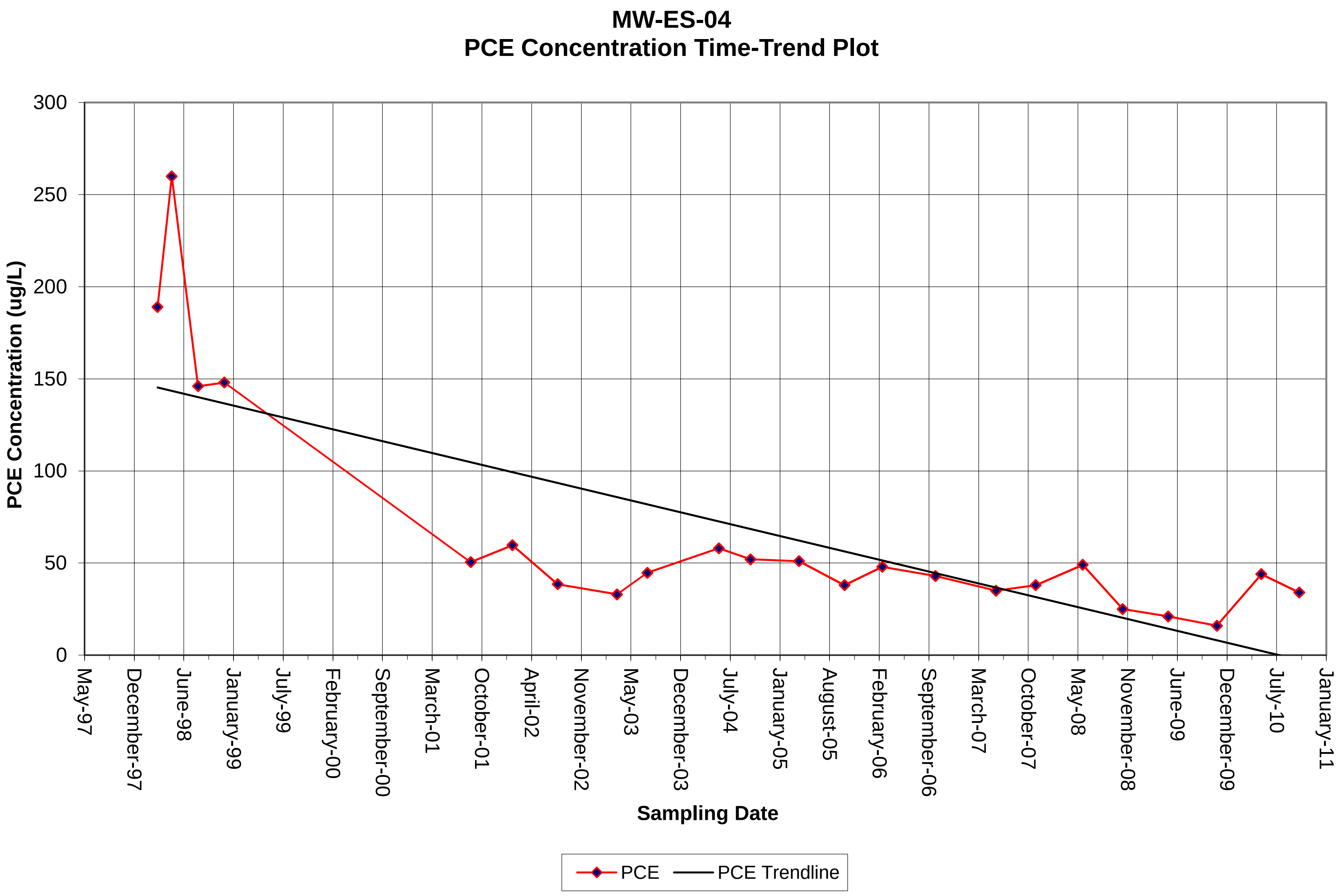
MW-UI
TCE Concentration Time-Trend Plot
PCE Concentration (ug/L)
30
25
20
15
10
5
0
September-00
March-01
October-01
April-02
November-02
May-03
December-03
July-04
January-05
August-05
February-06
September-06
March-07
October-07
May-08
November-08
June-09
December-09
July-10
January-11
Sampling Date
TCE
TCE Trendline

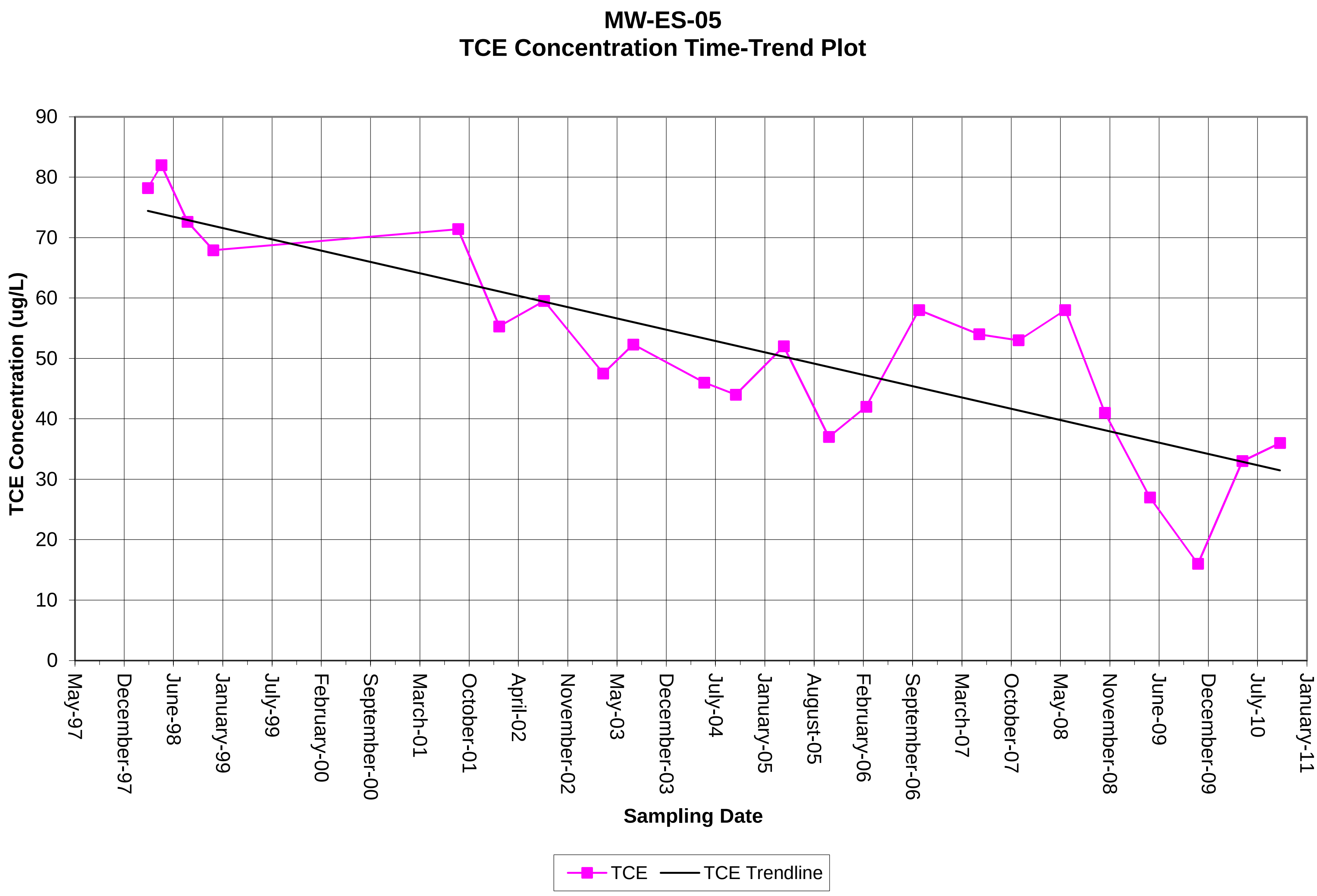

MW-ES-02
TCE Concentration Time-Trend Plot
TCE Concentration (ug/L)
100
90
80
70
60
50
40
30
20
10
0
January-06
April-06
July-06
October-06
January-07
April-07
July-07
October-07
January-08
April-08
July-08
October-08
January-09
April-09
July-09
October-09
January-10
April-10
July-10
October-10
January-11
Sampling Date
TCE
TCE Trendline

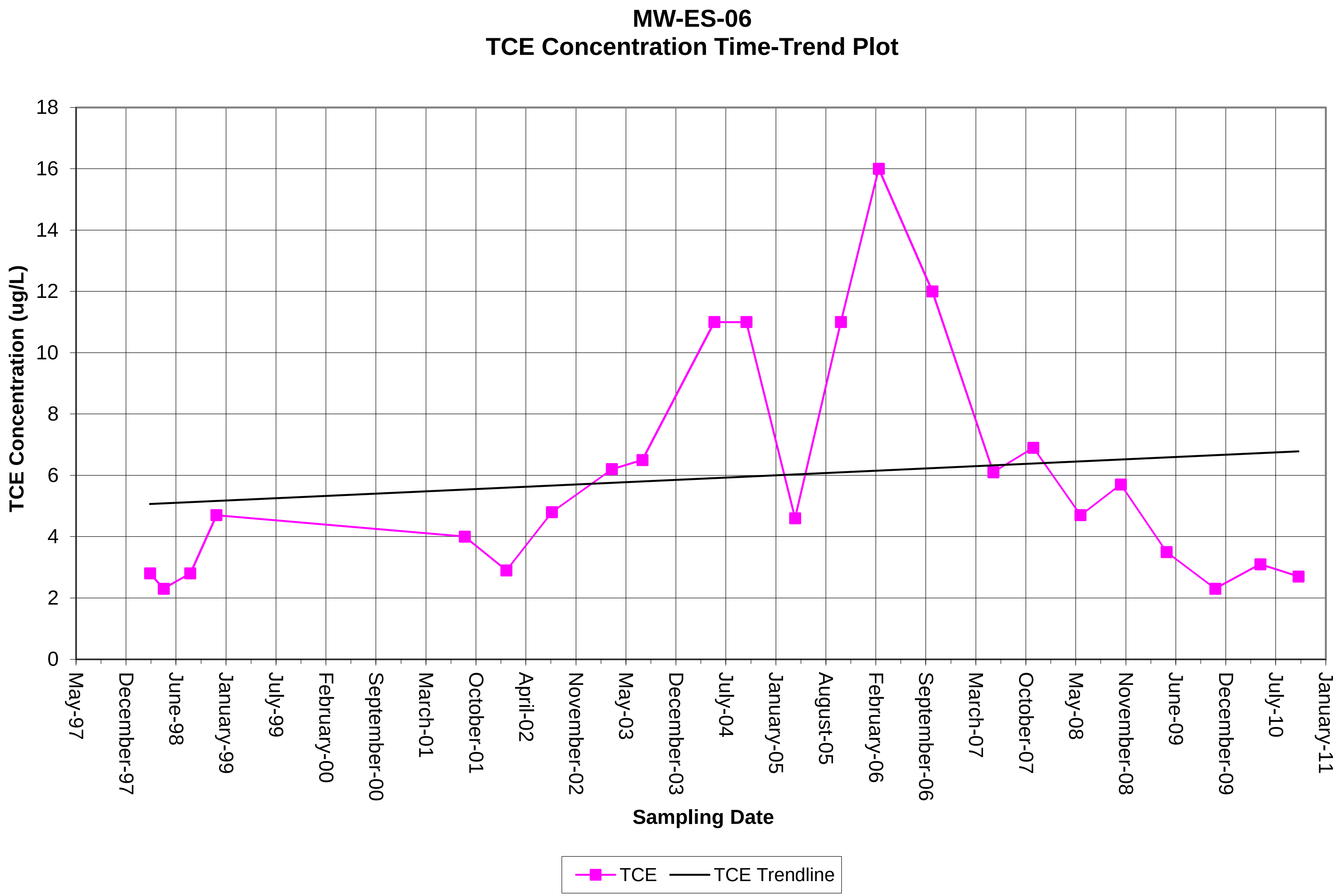

MW-ES-03
TCE Concentration Time-Trend Plot
TCE Concentration (ug/L)
0
10
20
30
40
50
60
70
80
90
May-97
December-97
June-98
January-99
July-99
February-00
September-00
March-01
October-01
April-02
November-02
May-03
December-03
July-04
January-05
August-05
February-06
September-06
March-07
October-07
May-08
November-08
June-09
December-09
July-10
January-11
Sampling Date
TCE
TCE Trendline



MW-ES-04
TCE Concentration Time-Trend Plot
TCE Concentration (ug/L)
3
2.5
2
1.5
1
0.5
0
May-97
December-97
June-98
January-99
July-99
February-00
September-00
March-01
October-01
April-02
November-02
May-03
December-03
July-04
January-05
August-05
February-06
September-06
March-07
October-07
May-08
November-08
June-09
December-09
July-10
January-11
Sampling Date
TCE
TCE Trendline

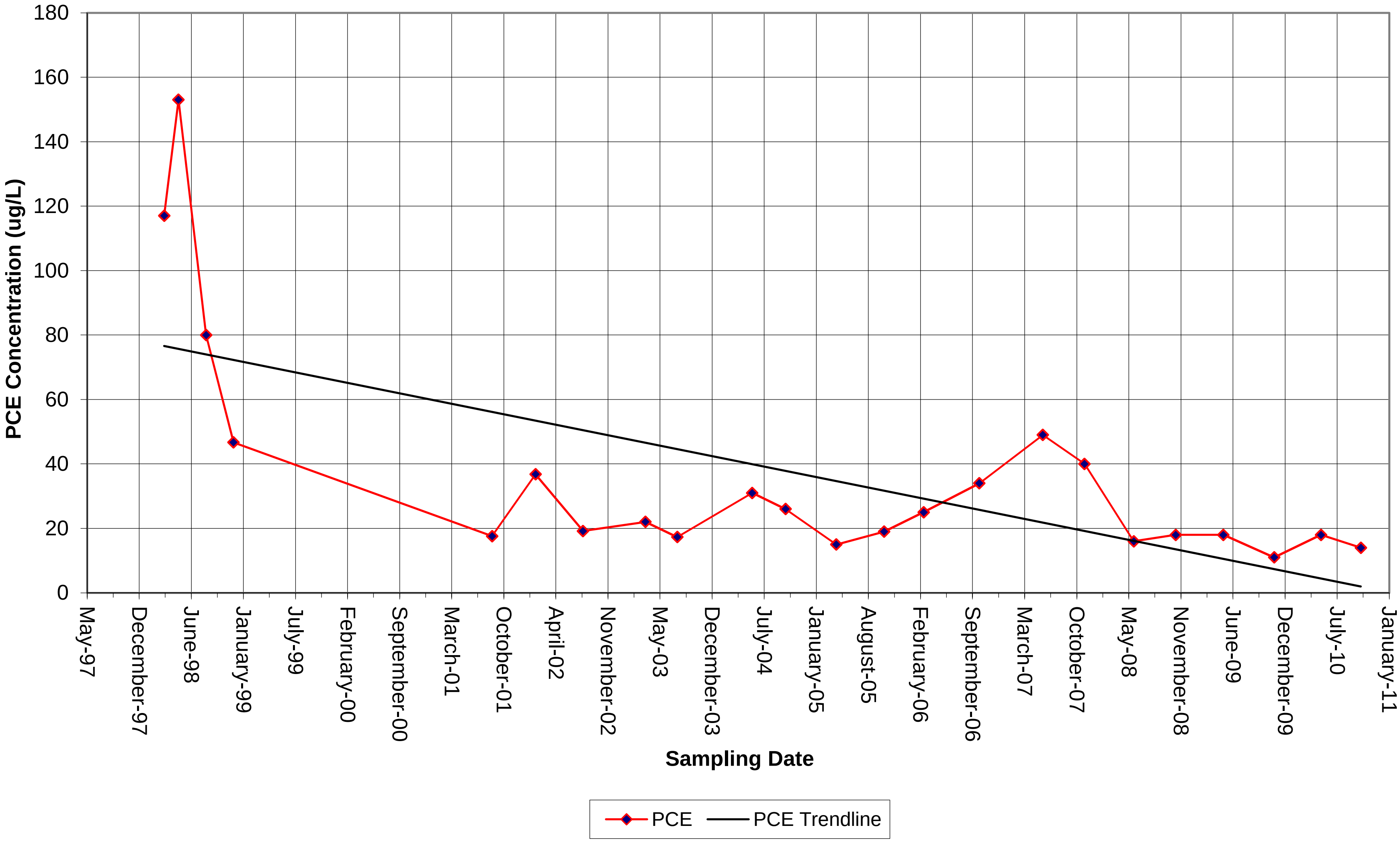

MW-ES-04
PCE Concentration Time-Trend Plot
PCE Concentration (ug/L)
300
250
200
150
100
50
0
May-97
December-97
June-98
January-99
July-99
February-00
September-00
March-01
October-01
April-02
November-02
May-03
December-03
July-04
January-05
August-05
February-06
September-06
March-07
October-07
May-08
November-08
June-09
December-09
July-10
January-11
Sampling Date
PCE
PCE Trendline


MW-ES-05
TCE Concentration Time-Trend Plot
TCE Concentration (ug/L)
0
10
20
30
40
50
60
70
80
90
May-97
December-97
June-98
January-99
July-99
February-00
September-00
March-01
October-01
April-02
November-02
May-03
December-03
July-04
January-05
August-05
February-06
September-06
March-07
October-07
May-08
November-08
June-09
December-09
July-10
January-11
Sampling Date
TCE
TCE Trendline

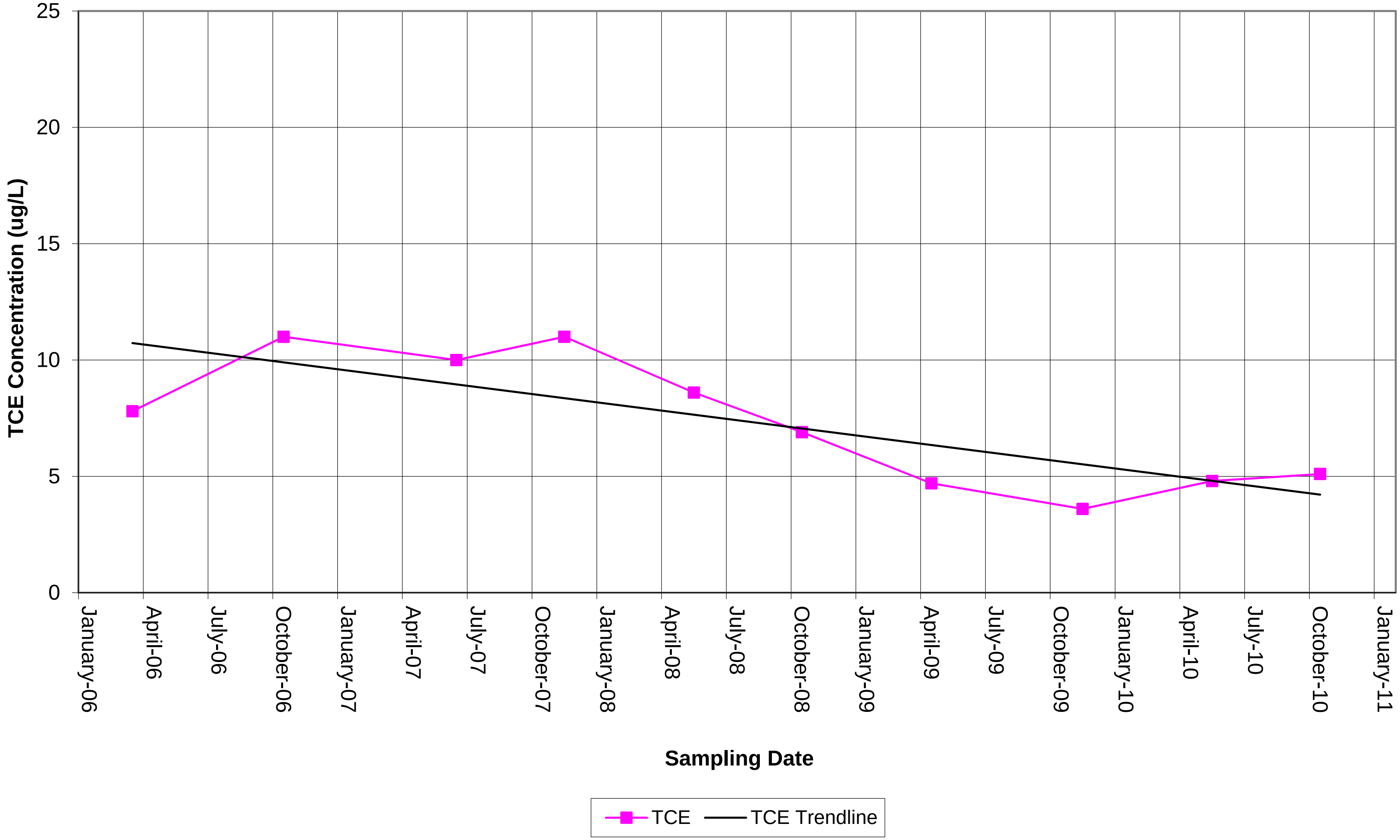


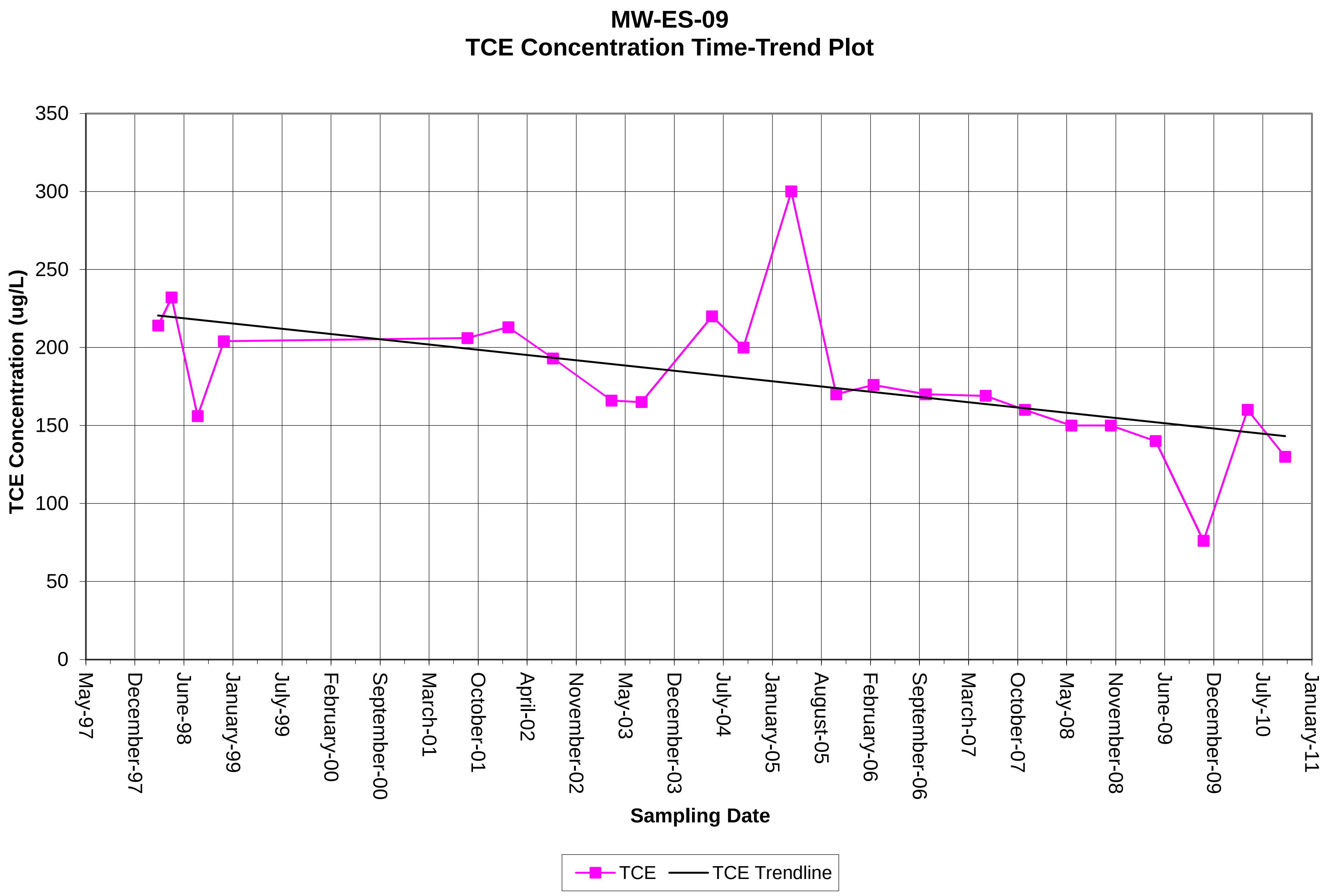
MW-ES-06
TCE Concentration Time-Trend Plot
TCE Concentration (ug/L)
18
16
14
12
10
8
6
4
2
0
May-97
December-97
June-98
January-99
July-99
February-00
September-00
March-01
October-01
April-02
November-02
May-03
December-03
July-04
January-05
August-05
February-06
September-06
March-07
October-07
May-08
November-08
June-09
December-09
July-10
January-11
Sampling Date
TCE
TCE Trendline

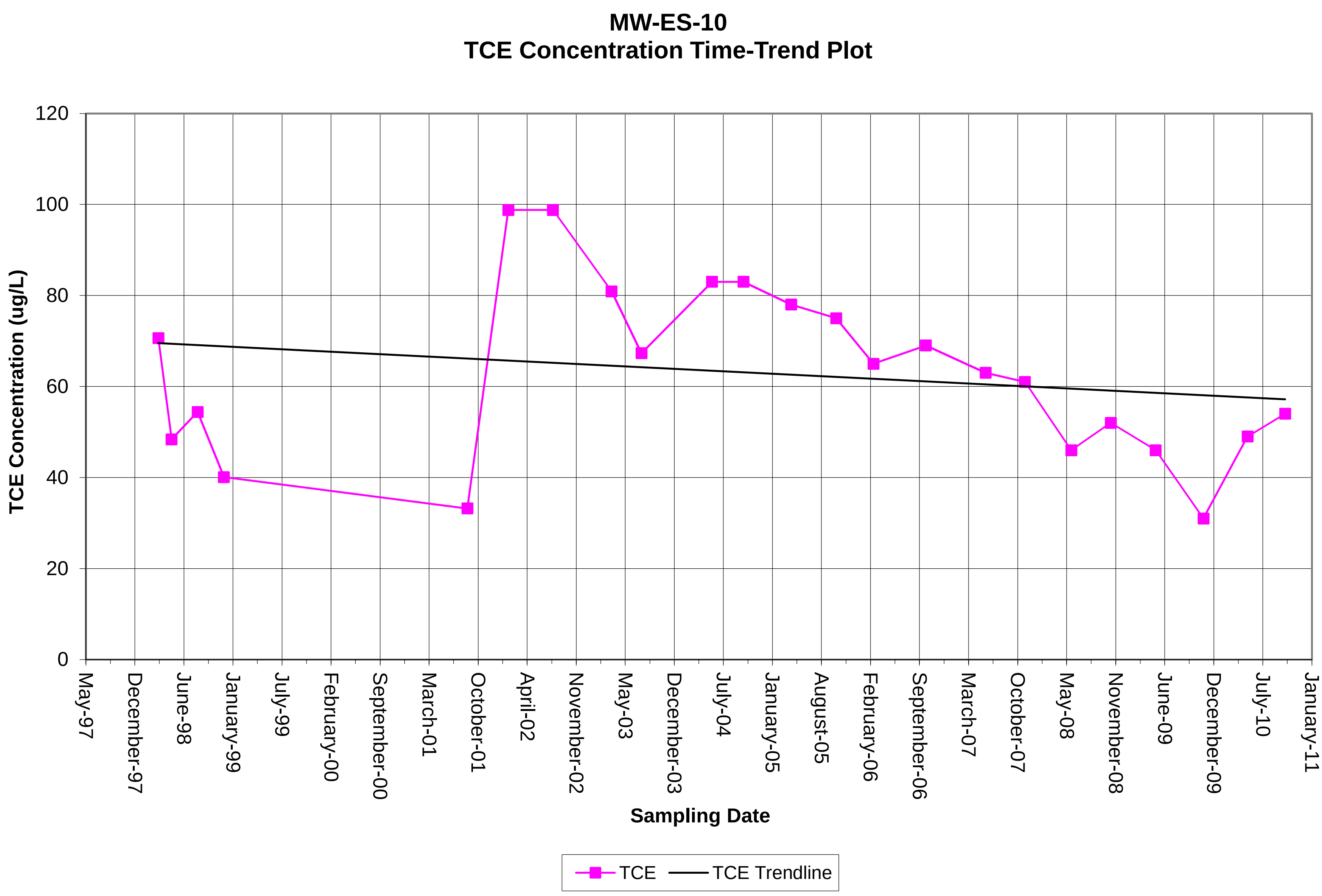
MW-ES-06
PCE Concentration Time-Trend Plot



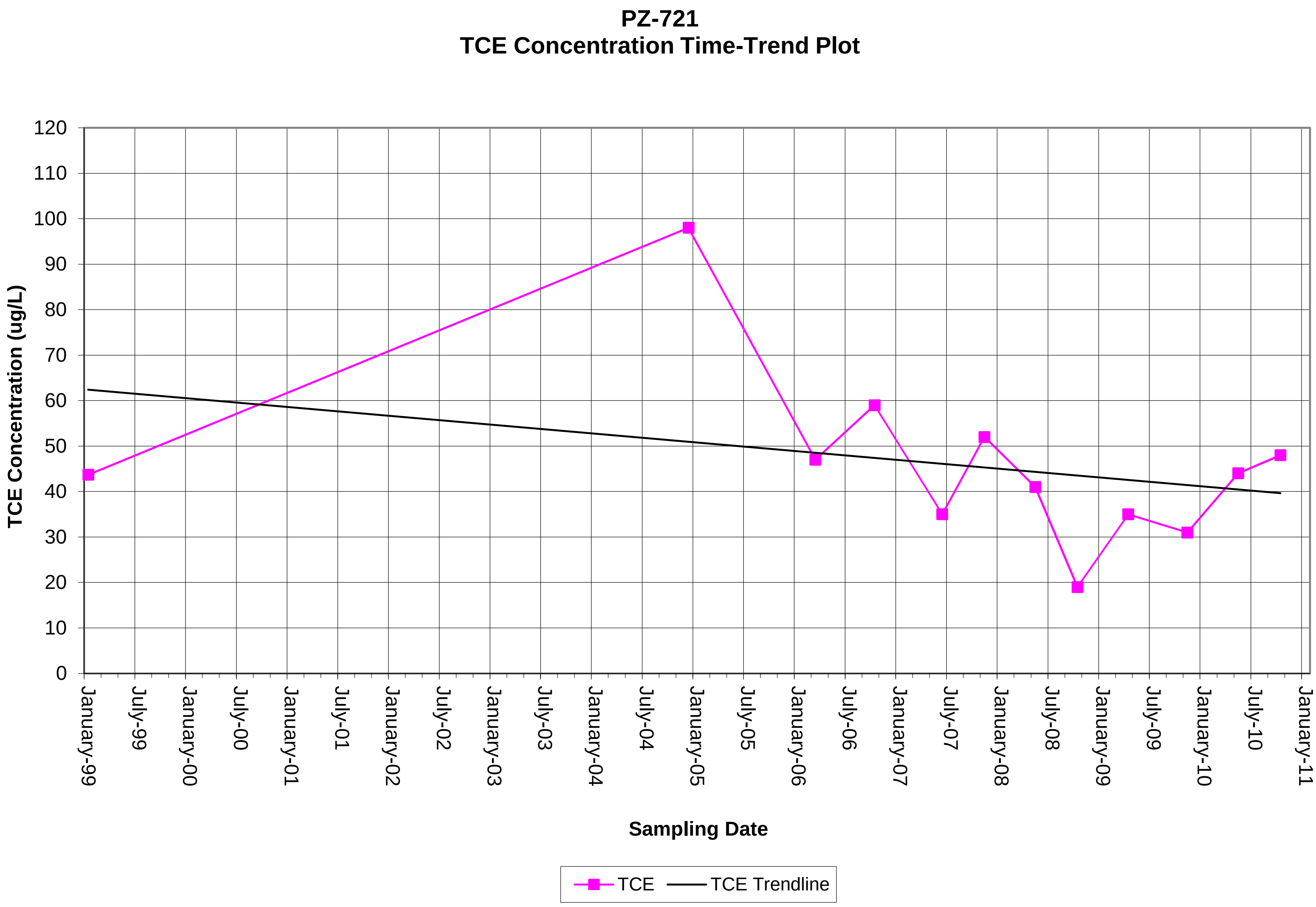
MW-ES-07
TCE Concentration Time-Trend Plot



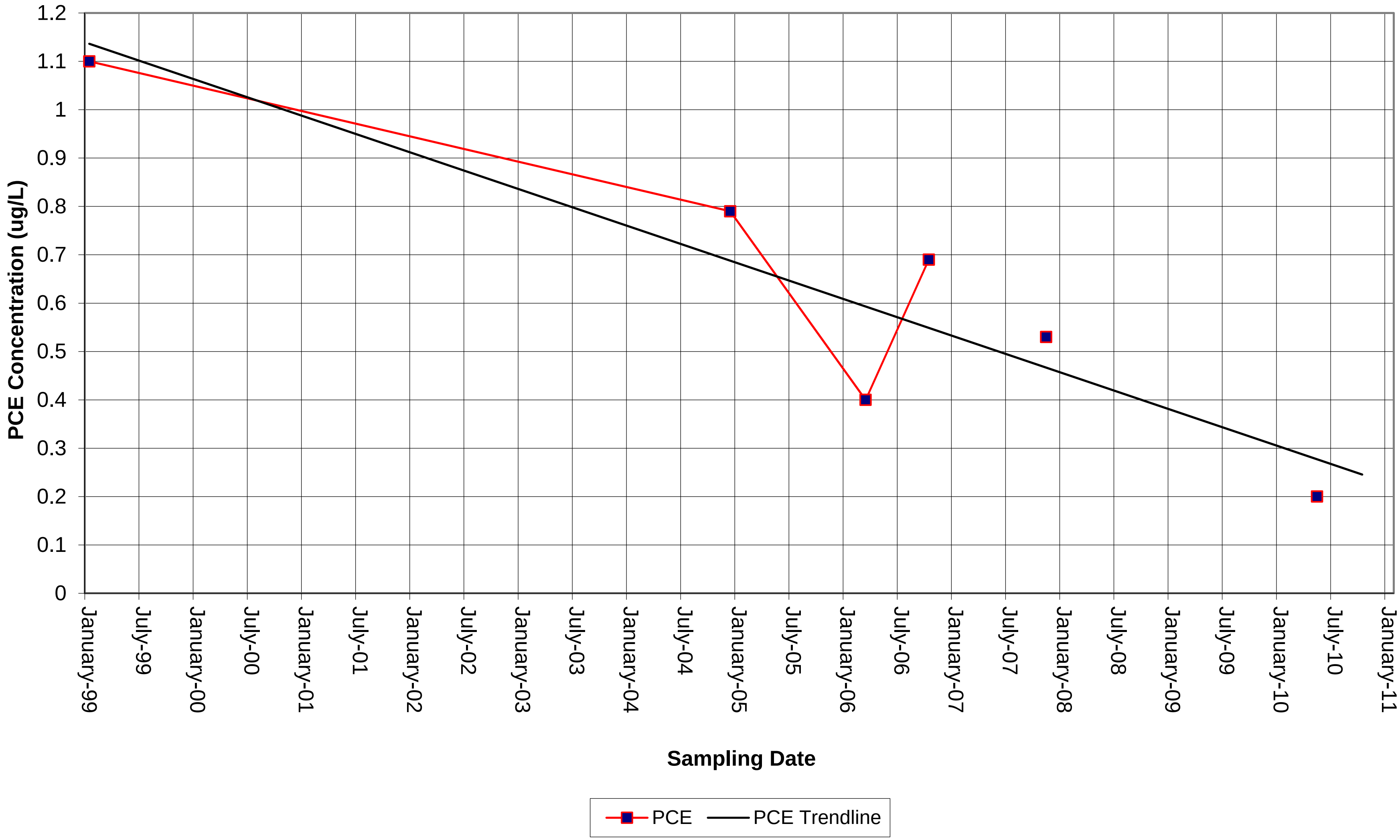

MW-ES-09
TCE Concentration Time-Trend Plot
TCE Concentration (ug/L)
350
300
250
200
150
100
50
0
May-97
December-97
June-98
January-99
July-99
February-00
September-00
March-01
October-01
April-02
November-02
May-03
December-03
July-04
January-05
August-05
February-06
September-06
March-07
October-07
May-08
November-08
June-09
December-09
July-10
January-11
Sampling Date
TCE
TCE Trendline



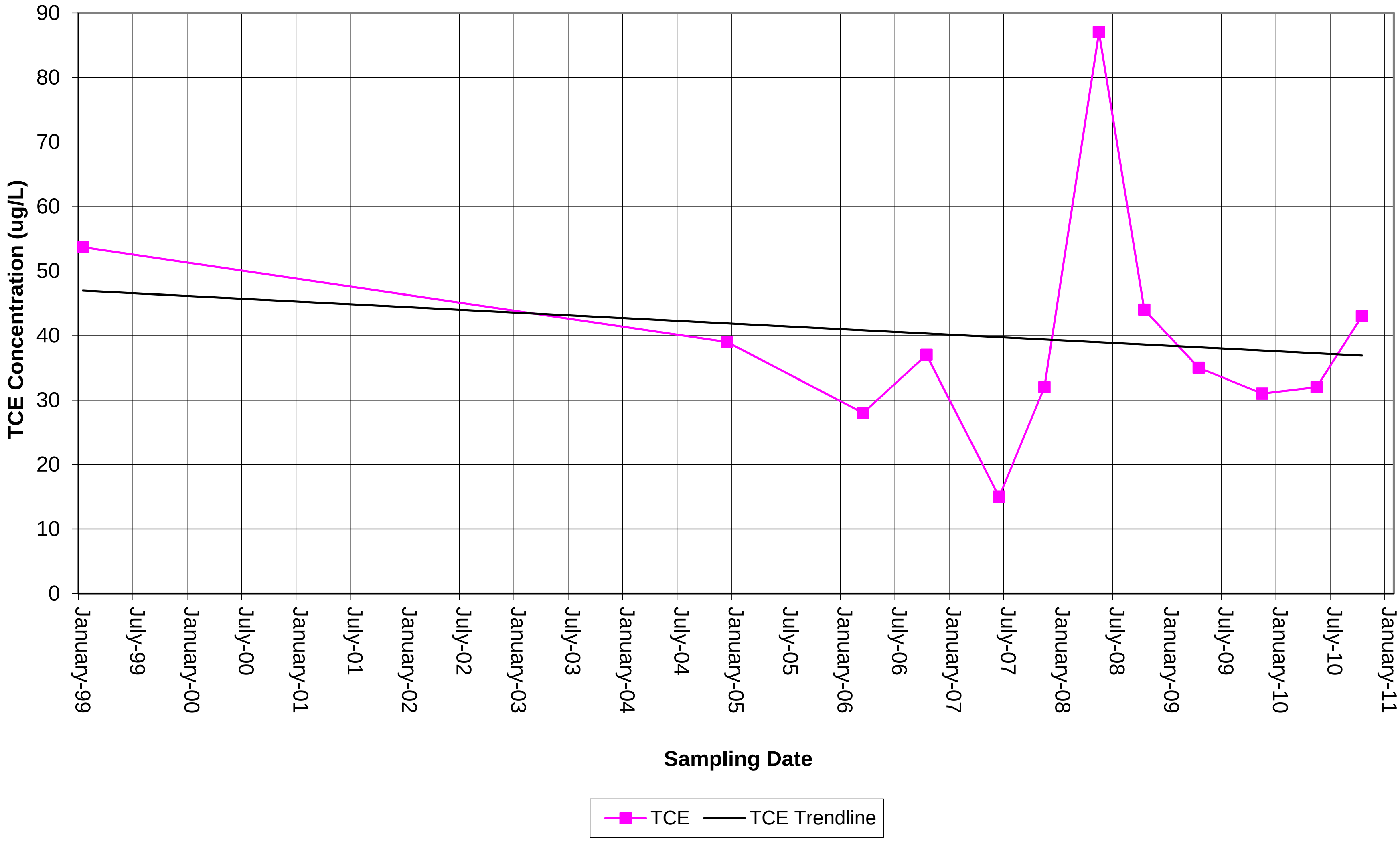
MW-ES-10
TCE Concentration Time-Trend Plot
TCE Concentration (ug/L)
0
20
40
60
80
100
120
May-97
December-97
June-98
January-99
July-99
February-00
September-00
March-01
October-01
April-02
November-02
May-03
December-03
July-04
January-05
August-05
February-06
September-06
March-07
October-07
May-08
November-08
June-09
December-09
July-10
January-11
Sampling Date
TCE
TCE Trendline


PZ-721
TCE Concentration Time-Trend Plot
TCE Concentration (ug/L)
0
10
20
30
40
50
60
70
80
90
100
110
120
January-99
July-99
January-00
July-00
January-01
July-01
January-02
July-02
January-03
July-03
January-04
July-04
January-05
July-05
January-06
July-06
January-07
July-07
January-08
July-08
January-09
July-09
January-10
July-10
January-11
Sampling Date
TCE
TCE Trendline

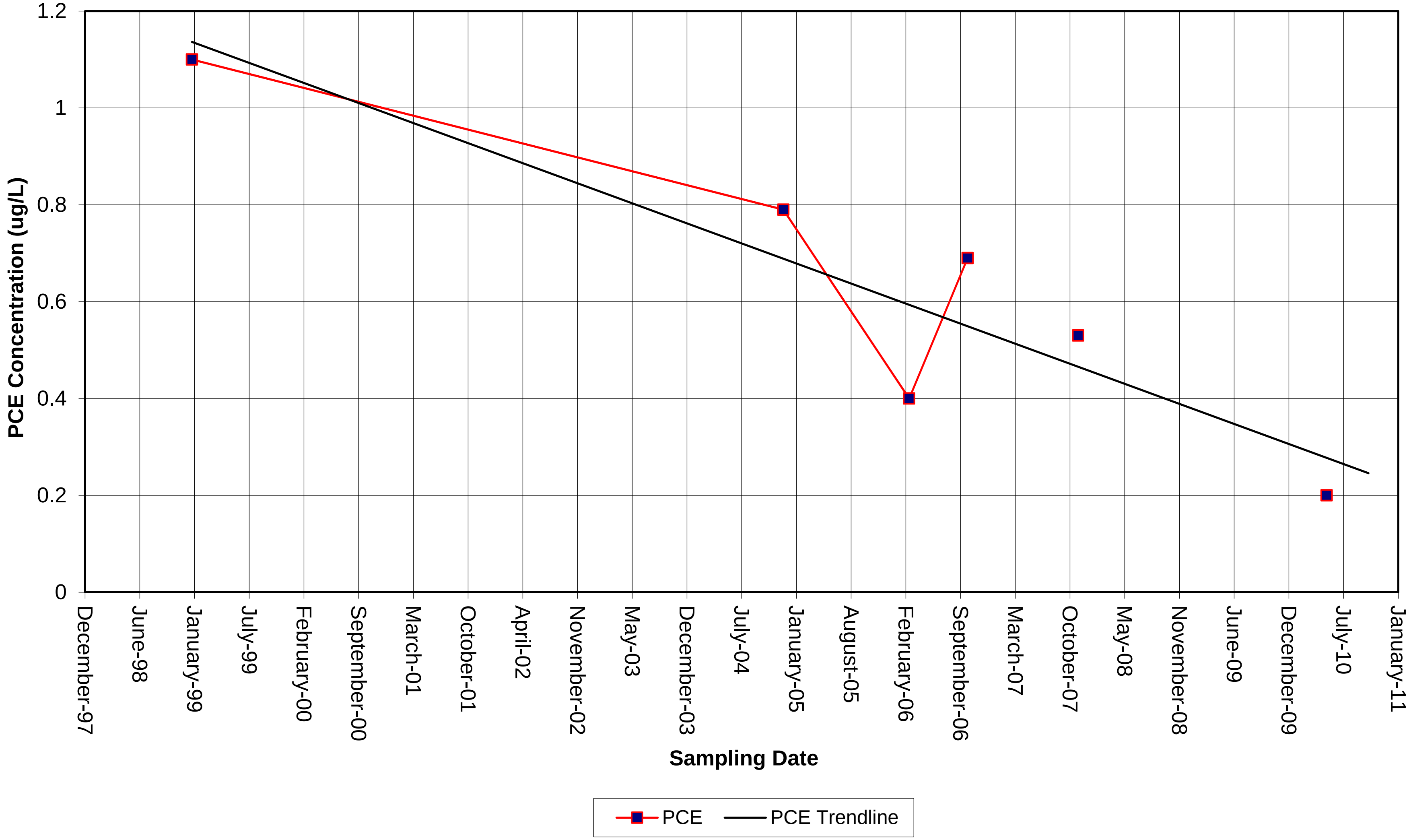
PZ-721
PCE Concentration Time-Trend Plot



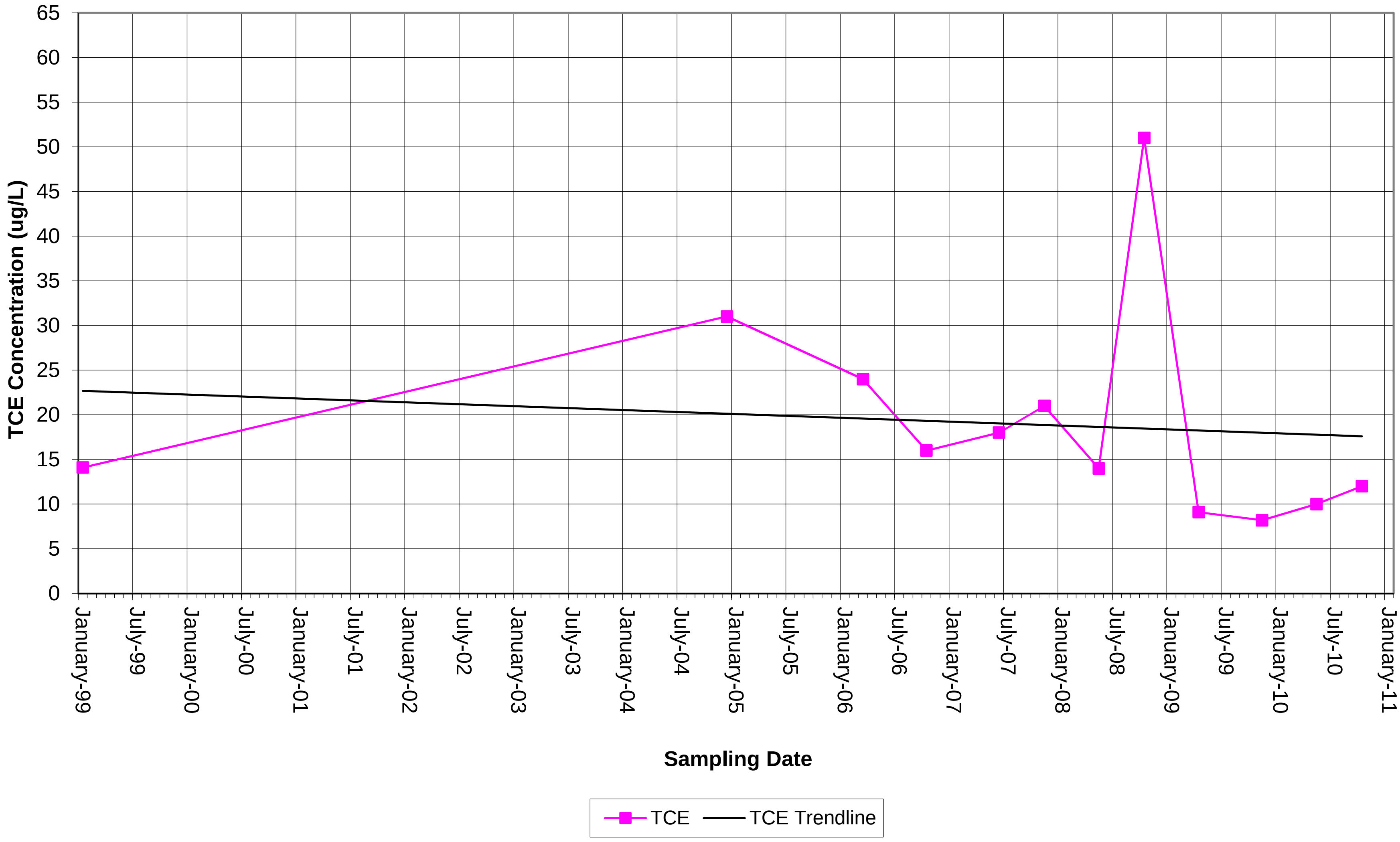
PZ-724
TCE Concentration Time-Trend Plot



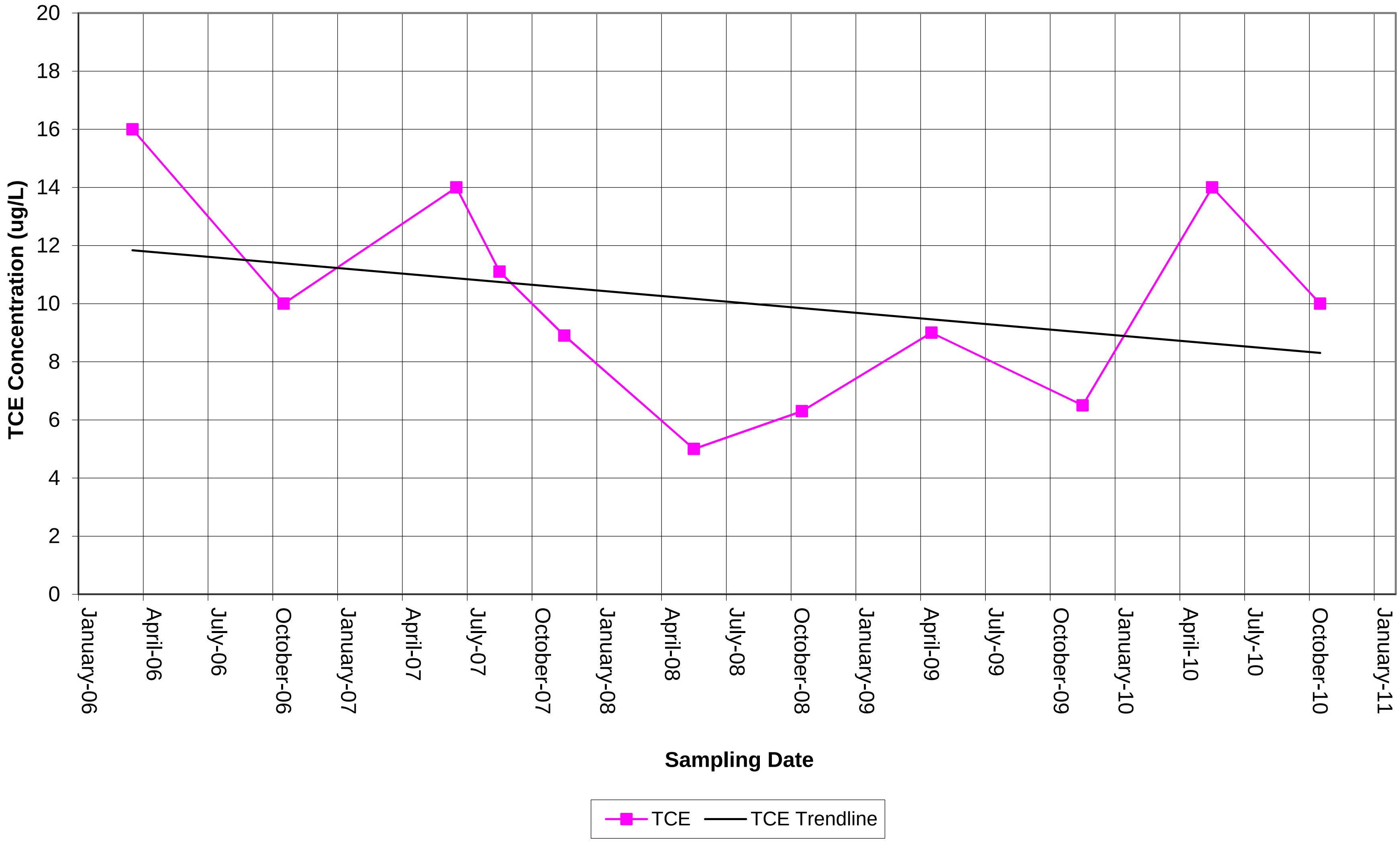
PZ-724
PCE Concentration Time-Trend Plot

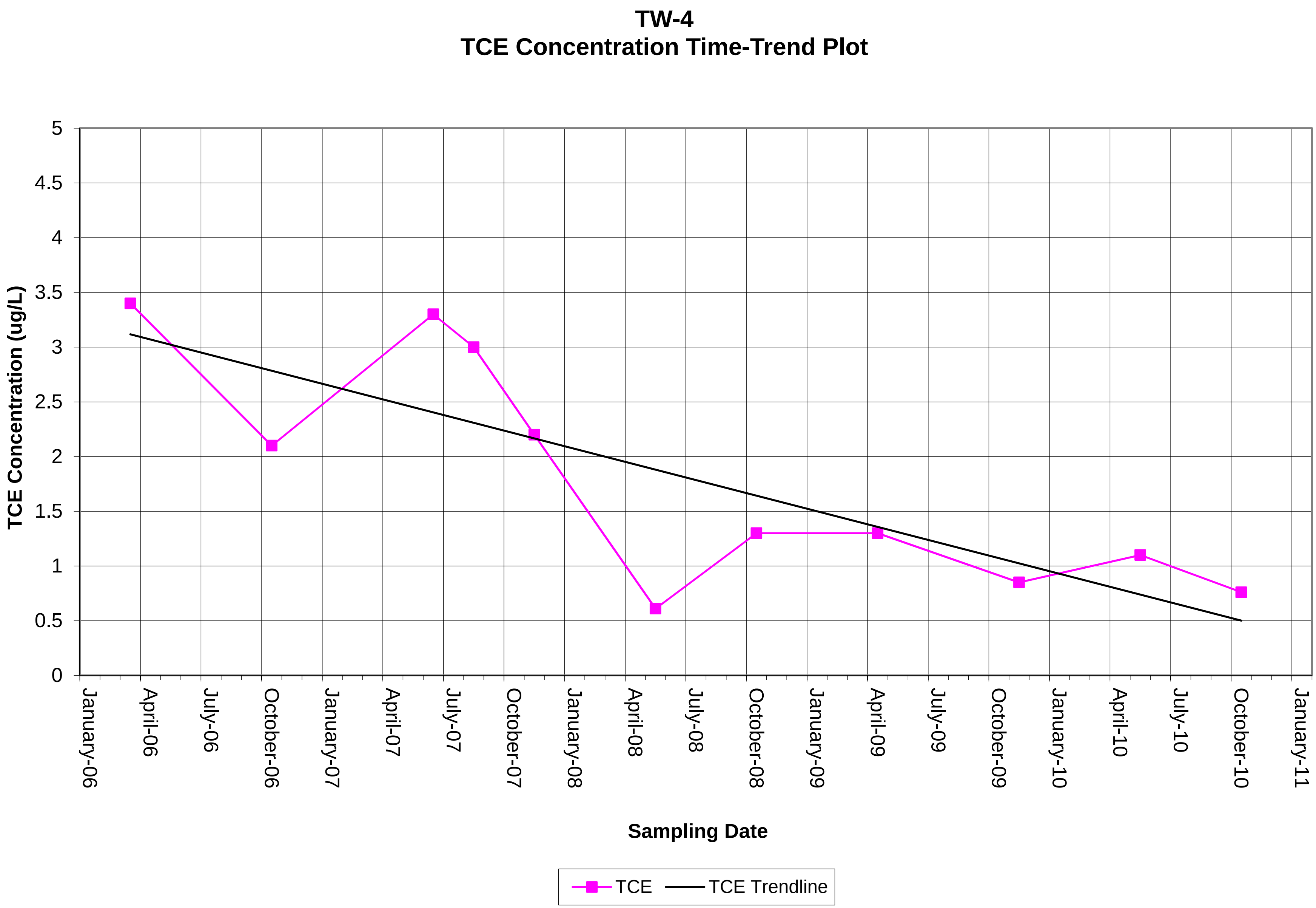


PZ-728
TCE Concentration Time-Trend Plot

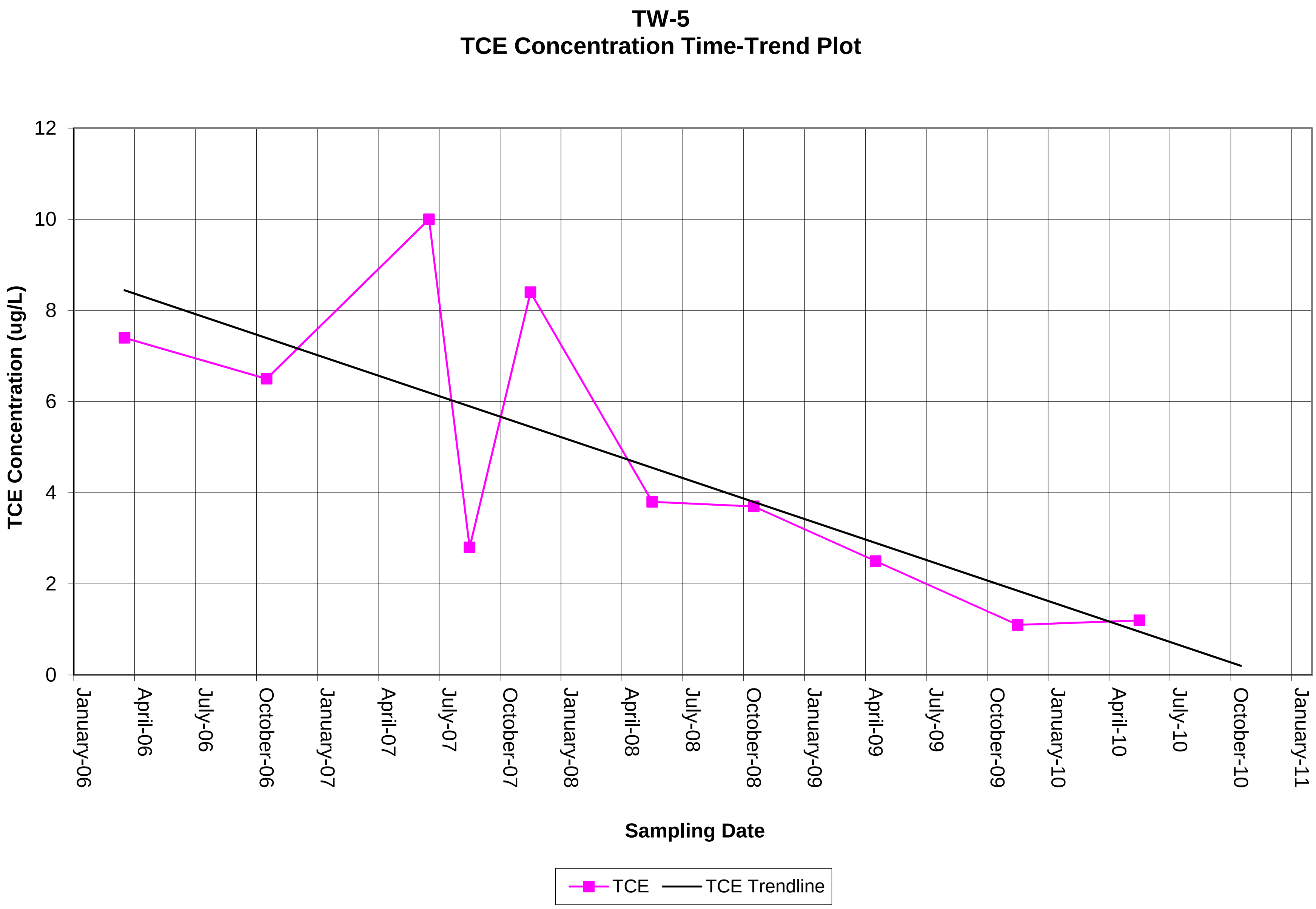


TW-2
TCE Concentration Time-Trend Plot

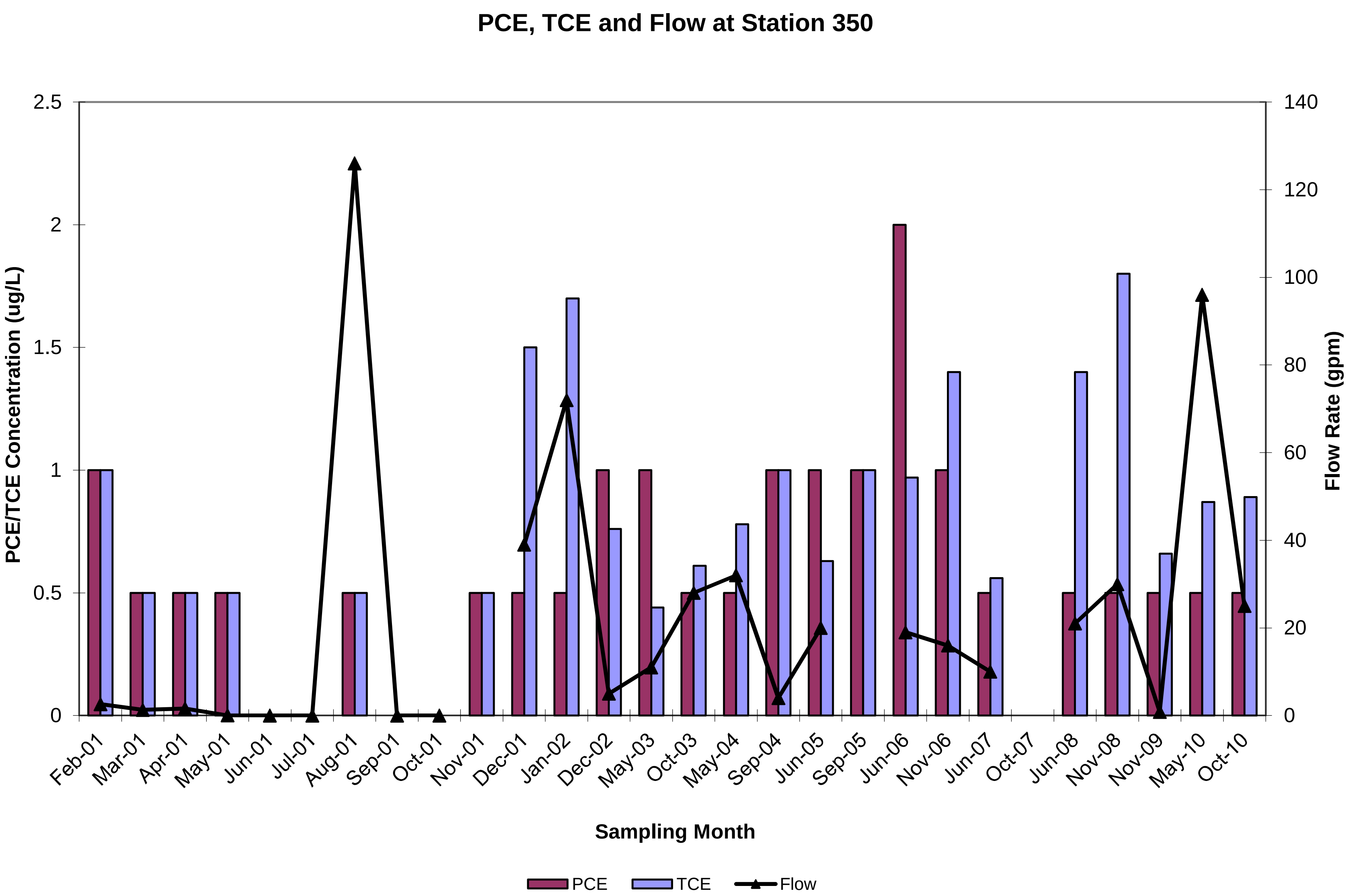




TW-4
TCE Concentration Time-Trend Plot
TCE Concentration (ug/L)
5
4.5
4
3.5
3
2.5
2
1.5
1
0.5
0
January-06
April-06
July-06
October-06
January-07
April-07
July-07
October-07
January-08
April-08
July-08
October-08
January-09
April-09
July-09
October-09
January-10
April-10
July-10
October-10
January-11
Sampling Date
TCE
TCE Trendline


TW-5
TCE Concentration Time-Trend Plot
TCE Concentration (ug/L)
0
2
4
6
8
10
12
January-06
April-06
July-06
October-06
January-07
April-07
July-07
October-07
January-08
April-08
July-08
October-08
January-09
April-09
July-09
October-09
January-10
April-10
July-10
October-10
January-11
Sampling Date
TCE
TCE Trendline

ATTACHMENT D



PCE, TCE and Flow at Station 350
PCE/TCE Concentration (ug/L)
Flow Rate (gpm)
Sampling Month
0
0.5
1
1.5
2
2.5
0
20
40
60
80
100
120
140
Feb-01
Mar-01
Apr-01
May-01
Jun-01
Jul-01
Aug-01
Sep-01
Oct-01
Nov-01
Dec-01
Jan-02
Dec-02
May-03
Oct-03
May-04
Sep-04
Jun-05
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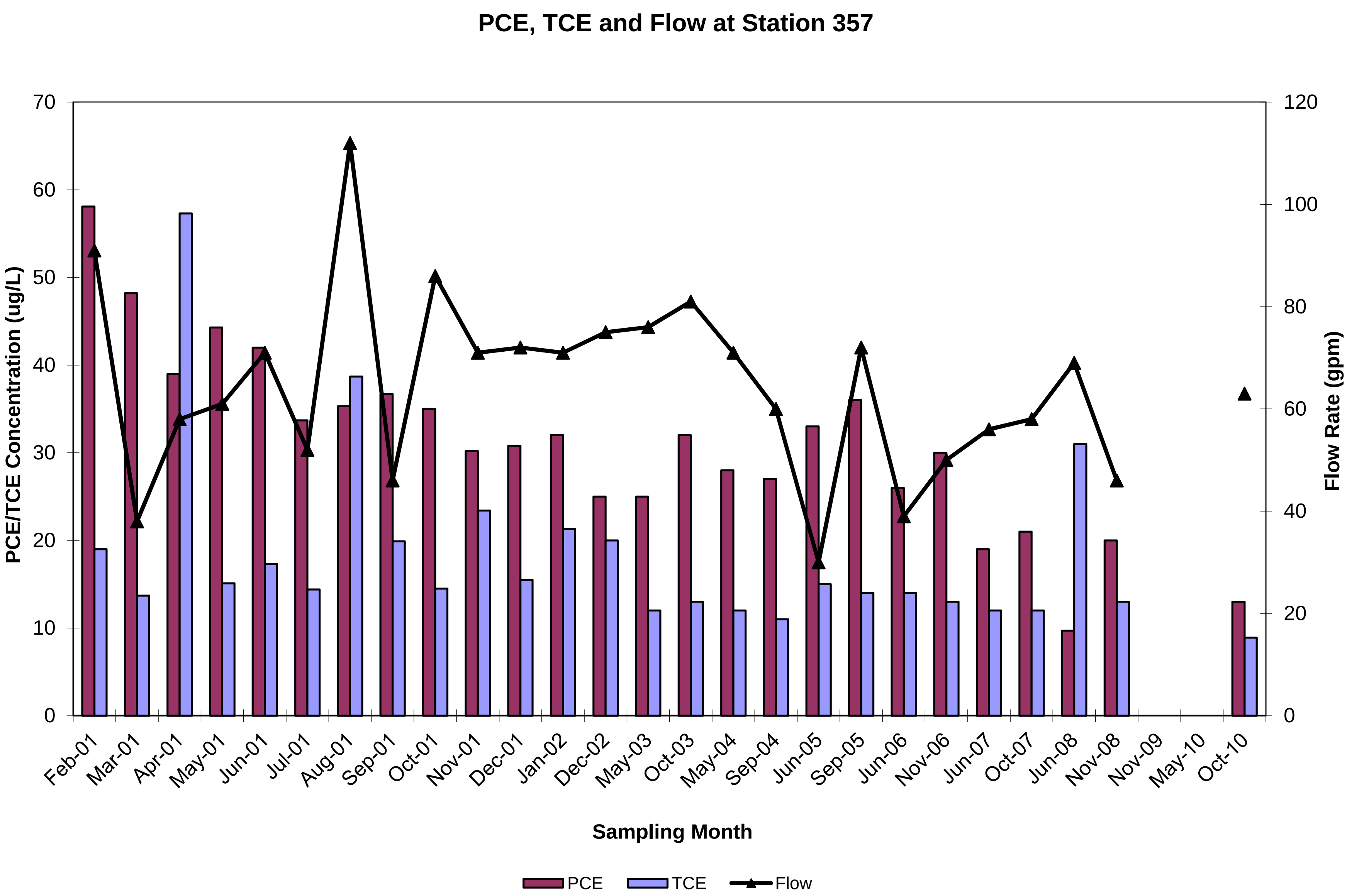
Jun-08
Nov-08
Nov-09
May-10
Oct-10
PCE
TCE
Flow


PCE, TCE and Flow at Station 357
PCE/TCE Concentration (ug/L)
Flow Rate (gpm)
Sampling Month
0
10
20
30
40
50
60
70
0
20
40
60
80
100
120
Feb-01
Mar-01
Apr-01
May-01
Jun-01
Jul-01
Aug-01
Sep-01
Oct-01
Nov-01
Dec-01
Jan-02
Dec-02
May-03
Oct-03
May-04
Sep-04
Jun-05
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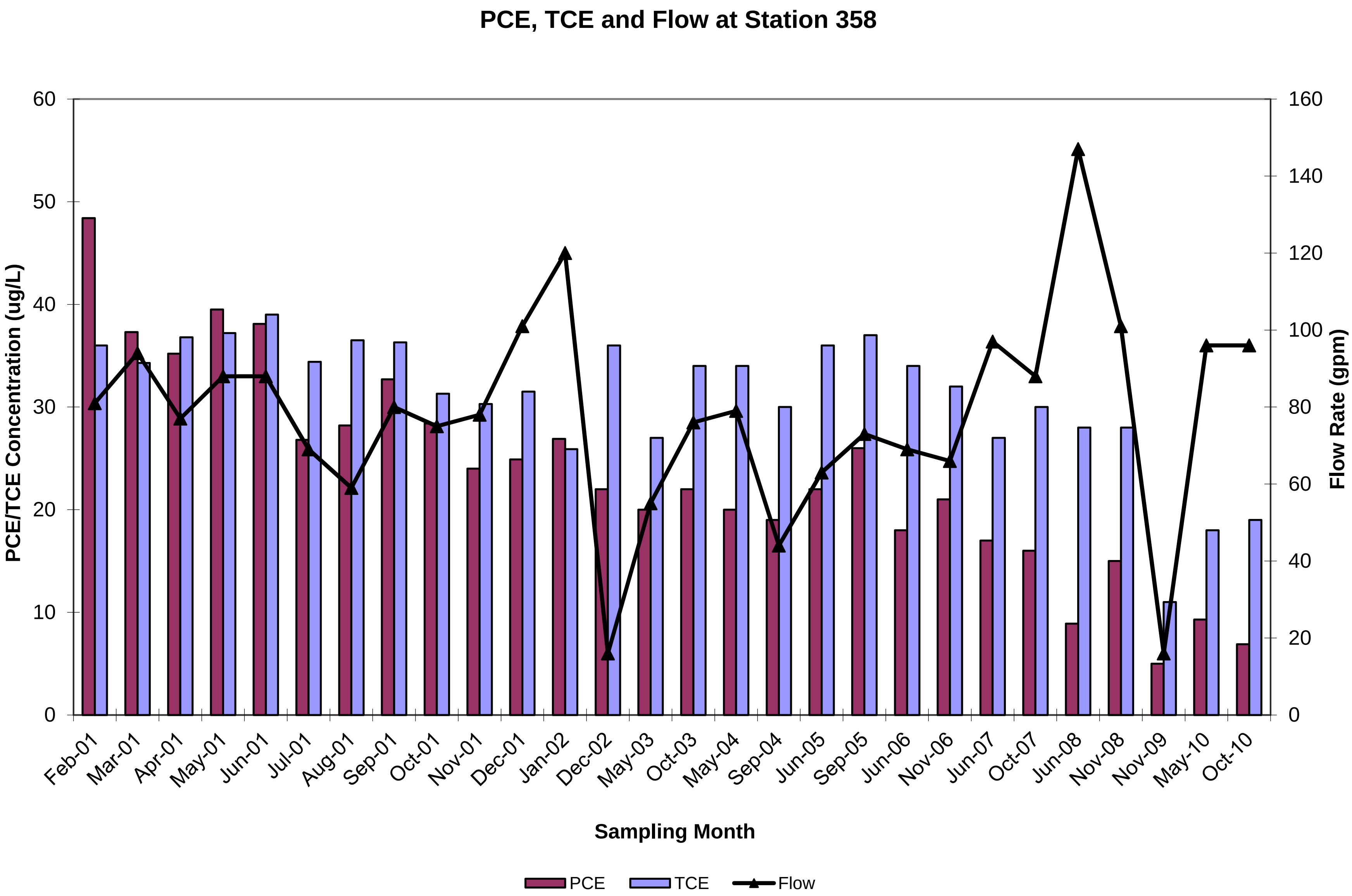
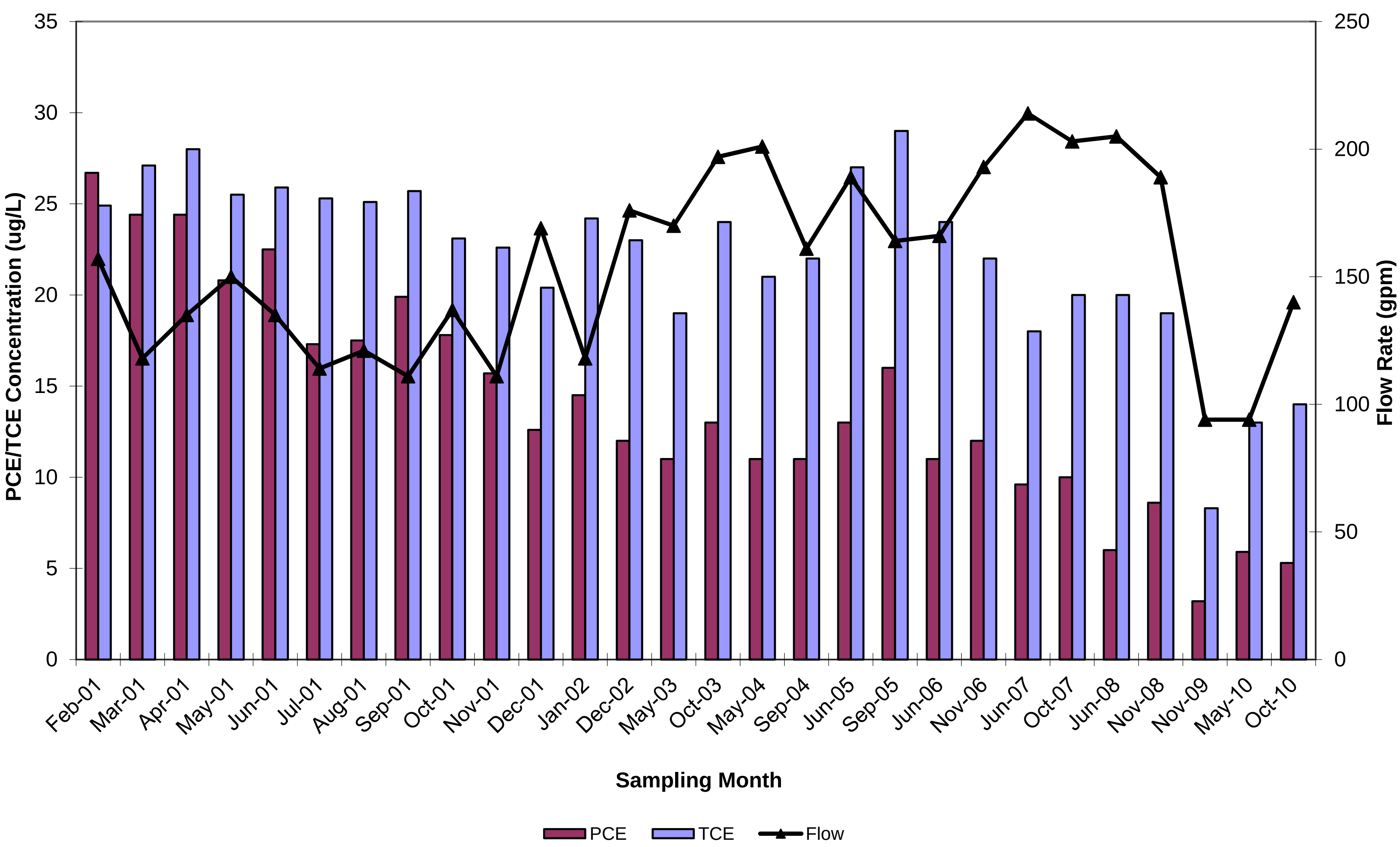
May-10
Oct-10
PCE
TCE
Flow

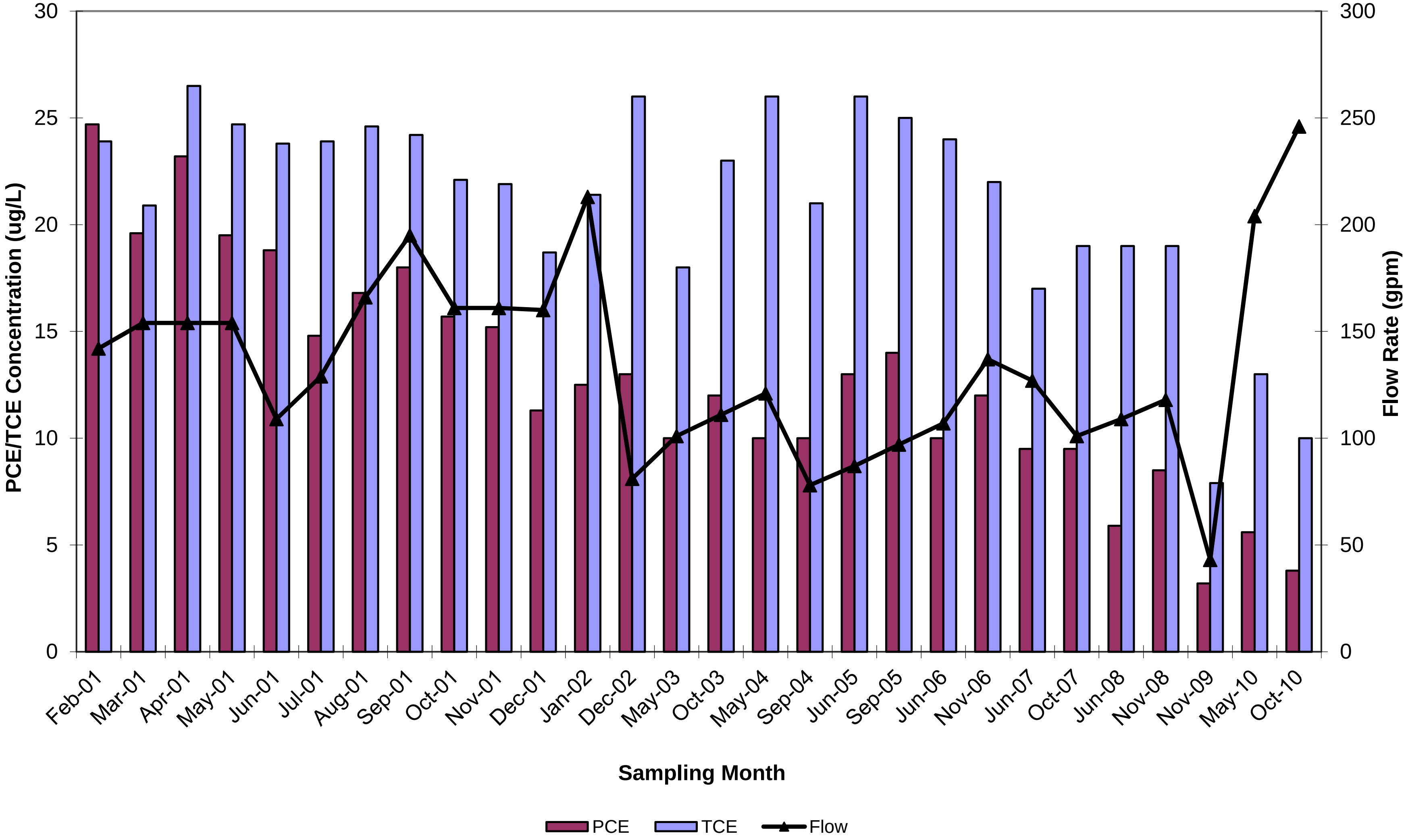


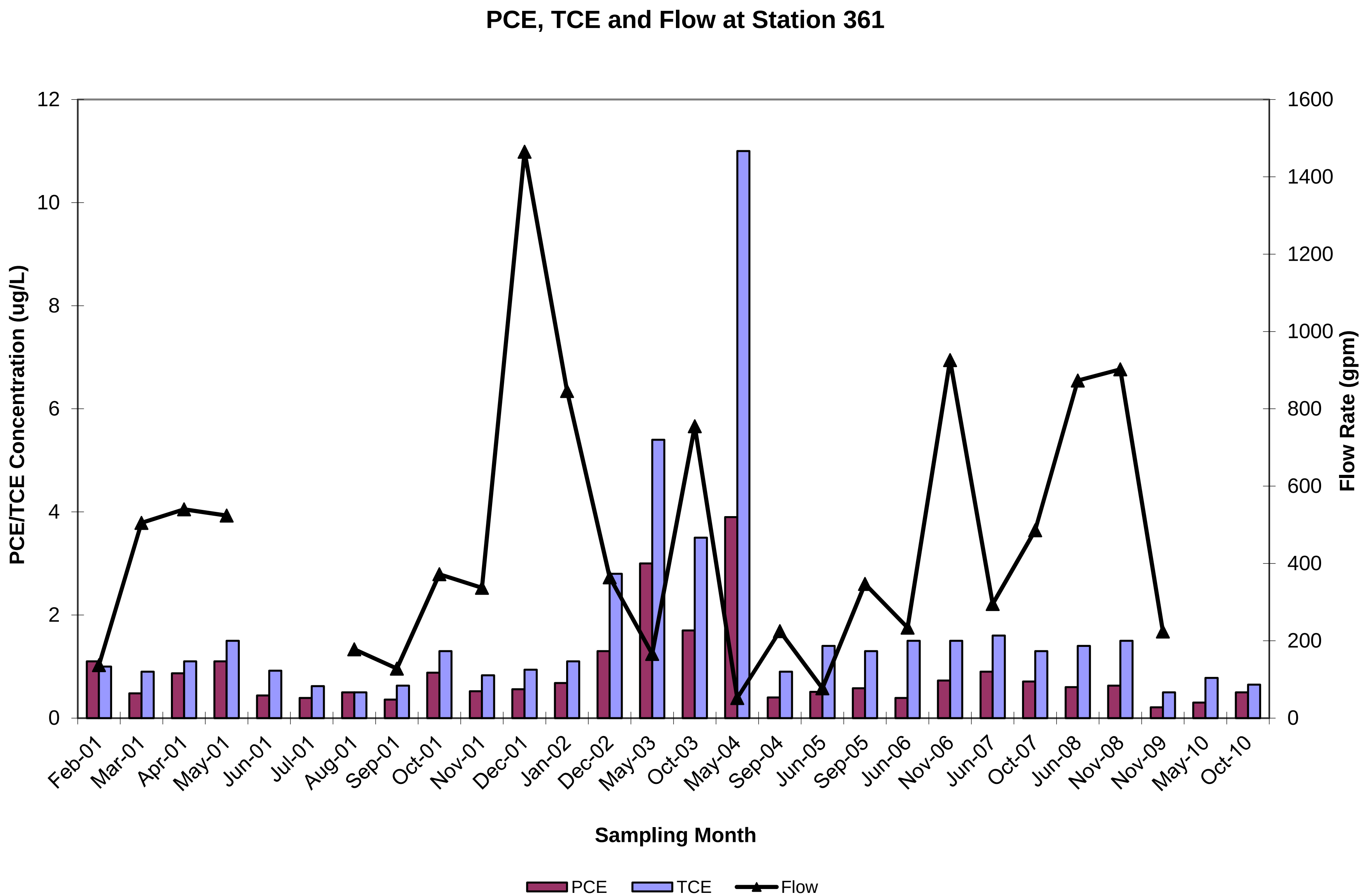
PCE, TCE and Flow at Station 358
PCE/TCE Concentration (ug/L)
Flow Rate (gpm)
Sampling Month
0
10
20
30
40
50
60
0
20
40
60
80
100
120
140
160
Feb-01
Mar-01
Apr-01
May-01
Jun-01
Jul-01
Aug-01
Sep-01
Oct-01
Nov-01
Dec-01
Jan-02
Dec-02
May-03
Oct-03
May-04
Sep-04
Jun-05
Sep-05
Jun-06
Nov-06
Jun-07
Oct-07
Jun-08
Nov-08
Nov-09
May-10
Oct-10
PCE
TCE
Flow

PCE, TCE and Flow at Station 359



PCE, TCE and Flow at Station 360





PCE, TCE and Flow at Station 361
PCE/TCE Concentration (ug/L)
Flow Rate (gpm)
Sampling Month
0
2
4
6
8
10
12
0
200
400
600
800
1000
1200
1400
1600
Feb-01
Mar-01
Apr-01
May-01
Jun-01
Jul-01
Aug-01
Sep-01
Oct-01
Nov-01
Dec-01
Jan-02
Dec-02
May-03
Oct-03
May-04
Sep-04
Jun-05
Sep-05
Jun-06
Nov-06
Jun-07
Oct-07
Jun-08
Nov-08
Nov-09
May-10
Oct-10
PCE
TCE
Flow

ATTACHMENT E

EXHIBIT A-8

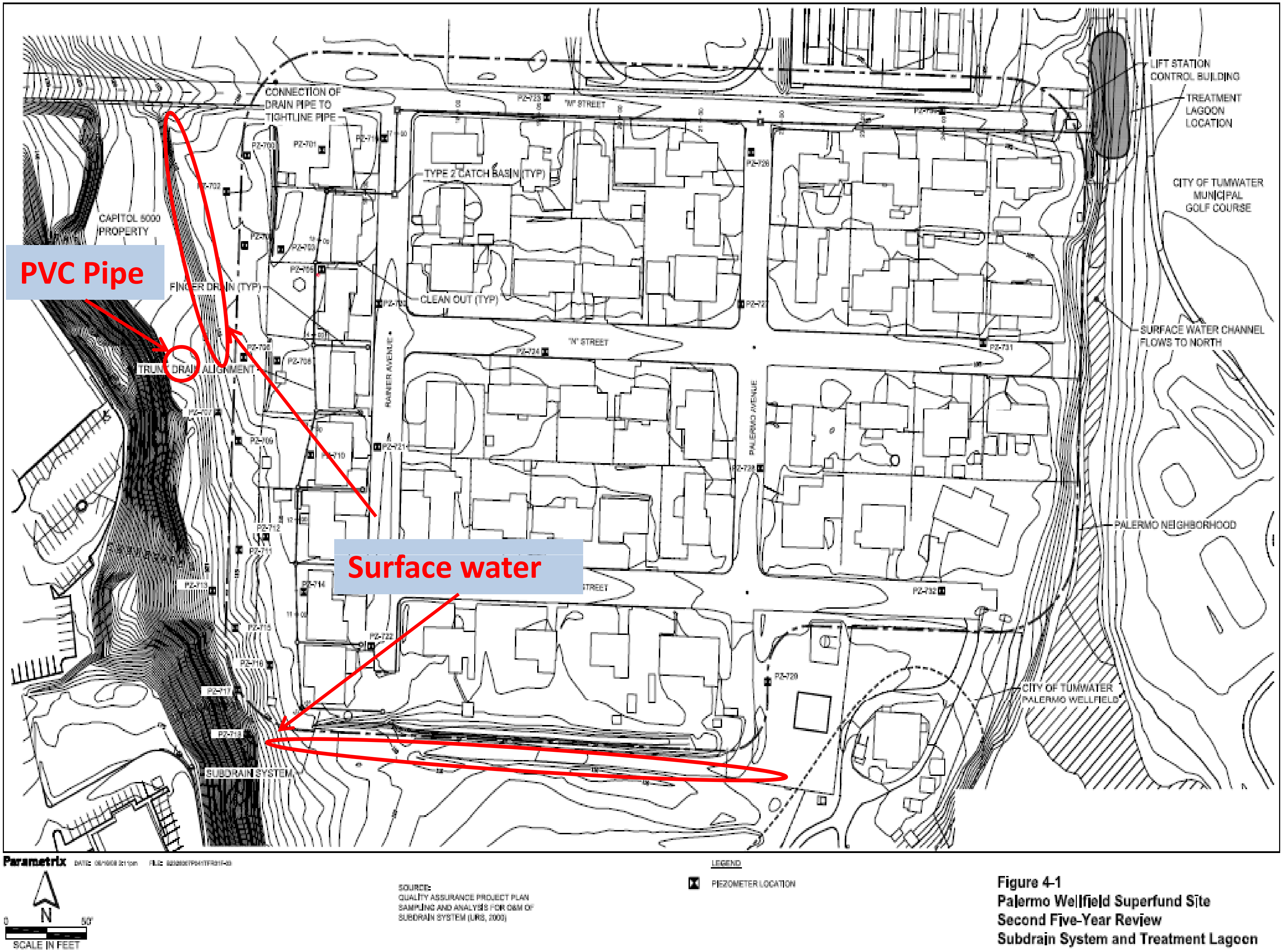


Figure 4-1
Palermo Wellfield Superfund Site
Second Five-Year Review
Subdrain System and Treatment Lagoon

ATTACHMENT F

PHOTO 1: Overview of Southgate Mall and Southgate Dry Cleaners, looking west.

PHOTO 2: Southgate Dry Cleaners lease space, looking northwest.

PHOTOGRAPHIC LOG
Palermo Superfund Site
Tumwater, Washington

August 25, 2011

PHOTO 3: Groundwater monitoring well and abandoned large diameter feature located in the parking lot south of Southgate Dry Cleaners.

PHOTO 4: Looking east from Southgate Mall parking lot toward Capitol Boulevard, with commercial businesses and the Palermo Valley Bluff beyond.

PHOTO 5: City of Tumwater Palermo Well Field – Dual air stripping towers within and above pump house and water treatment building, looking northeast.

PHOTO 6: City of Tumwater Palermo Well Field – Dual air stripping towers within and above pump house and water treatment building, looking southwest.

PHOTO 7: City of Tumwater Palermo Well Field – Dual air stripping towers within and above pump house and water treatment building, looking southwest.

PHOTO 8: City of Tumwater Palermo Well Field – Dual air stripping towers within and above pump house and water treatment building, looking east; note seep drainage in foreground.

PHOTO 9: City of Tumwater Palermo Well Field – Looking south toward stake marking proposed TW-2 well replacement location, with TW-2 well house in background.

PHOTO 10: City of Tumwater Palermo Well Field – Well house structures, looking east-northeast.

PHOTO 11: City of Tumwater Palermo Well Field – Looking northeast toward well house structures (left) and undeveloped land beyond.

PHOTO 12: City of Tumwater Palermo Well Field – Interior of Pump House.

PHOTO 13: City of Tumwater Palermo Well Field – Air Stripping Tower #2.

PHOTO 14: City of Tumwater Palermo Well Field – Chemical treatment container (sodium hypochlorite) - typically not used - air strippers used instead to adjust pH.

PHOTO 15: City of Tumwater Palermo Well Field – Air ducting for Blower No. 2 for Air Stripping Tower No. 2

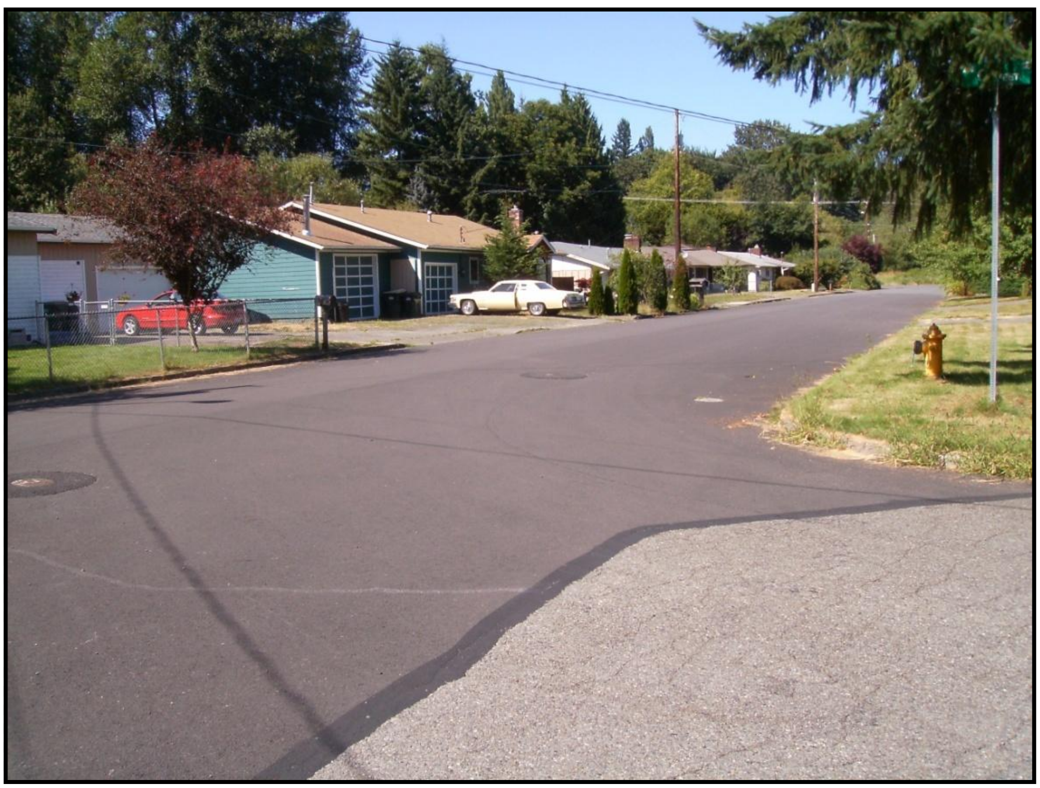


PHOTO 16: Overview of residential neighborhood.

PHOTO 17: Overview of residential neighborhood.

PHOTO 18: Overview of residential neighborhood.

PHOTO 19: Overview of residential neighborhood.

PHOTO 20: Typical residential perimeter foundation with crawl space; note crawl space ventilation.

PHOTO 21: Close-up of residential foundation showing crawlspace ventilation.

PHOTO 22: Seep drainage feature oriented west-east, south of House #6 at the southwest corner of the neighborhood, looking southeast.

PHOTO 23: Seep drainage feature oriented west-east, south of House #6 at the southwest corner of the neighborhood, looking southwest.

PHOTO 24: Looking south from M Street, west of House #1 at the northwest corner of the neighborhood, where seep drainage feature extends to the south, behind (west of) homes along Rainier Avenue.

PHOTO 25: Looking northwest at seep drainage south of neighborhood; view toward backyard of homes along O Street; seep drainage is oriented west-east.

PHOTO 26: Close-up of seep drainage south of O Street house, looking north-northwest.

PHOTO 27: View southwest along former Palermo Well Field access road, southwest of well field, ascending bluff.

PHOTO 28: Apparent groundwater monitoring well and two bumper posts along bluff.

PHOTO 29: Debris, including tires and wheels, along bluff west of residential neighborhood.

PHOTO 30: 8-inch diameter PVC pipe day-lighting along bluff west of residential neighborhood; location estimated to be 60 feet west of the northwest corner of House #4.

PHOTO 31: Another view of 8-inch diameter drainage pipe along bluff.

PHOTO 32: Drain Pipe Treatment Lagoon northeast of neighborhood; looking southeast, with golf course in background.

PHOTO 33: Drain Pipe Treatment Lagoon, looking northeast, with golf course in background.

PHOTO 34: Looking south toward up-stream end of Treatment Lagoon drainage feature.

PHOTO 35: Looking northeast toward downstream end of Treatment Lagoon drainage feature.

PHOTO 36: Looking east across Treatment Lagoon toward wells TW-20, TW-23 and TW-24.

ATTACHMENT G

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5150 Capitol Blvd SE
Olympia, WA 98501

Inquiry Number: 3167828.1
September 16, 2011

EDR Historical Topographic Map Report

EDR® Environmental Data Resources Inc

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